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CLEVELAND, OHIO NUMBER 30

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THE CLEVELAND MUSEUM OF NATURAL HISTORY

CLEVELAND, OHIO NUMBER 30

A NEW MILLIPEDE GENUS, *MYRIACANTHERPESTES* (DIPLOPODA, ARCHIPOLYPODA) AND A NEW SPECIES, *MYRIACANTHERPESTES BRADEBIRKSI*, FROM THE ENGLISH COAL MEASURES

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Abstract

The Archipolypoda are assigned ordinal rank in this paper and included in the Diplopoda because they show the typical diplosomite structures characteristic of that class. A complete definition of the taxon must await restudy of the material from the Stephanian of Europe. A more extensive summary is supplied for the archipolypod family Euphoberiidae, in which three genera, *Euphoberia*, *Acantherpestes*, and *Myriacantherpestes* gen. nov. are included. The type species of *Myriacantherpestes* is *Eurypterus*? (*Arthropleura*) *ferox* Salter, 1863. The genus differs from *Euphoberia* and *Acantherpestes* in having much longer lateral spines and in showing an additional (anterior) spinelet at the base which overlaps and interlocks with the posterior spinelet of the preceding diplosomite. The subdorsal spines are simple, without the anterior spinelet found in the subdorsals of *Euphoberia*, and may be elevated and spike-like, or bent outward, curving laterad, or reduced to nodes. Referred species, in addition to the type species, include *Myriacantherpestes inequalis* (Scudder) n. comb.; *M. hystricosus* (Scudder) n. comb.; *M. clarkorum* (Burke) n. comb. and *Myriacantherprestes bradebirksi* sp. nov. described herein and characterized by: (1) size (smallest species of the genus); (2) stout, evenly tapering lateral spines with prongs only slightly bowed; (3) anterior and posterior prongs not sharply divergent; and (4) anterior spinelet originating close to spine base. *Acantherpestes horridus* (Scudder) n. comb. is proposed in place of *Euphoberia horrida* Scudder, 1882.

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Introduction

Shortly after publication of my initial paper dealing with Upper Carboniferous archipolypod millipedes (Burke, 1973) I obtained better material representing the genus *Euphoberia*. This new evidence showed that contrary to my earlier observations, exsertile–sac pits were present in representatives of that genus, and that what I had termed dilatations were actually coxae, fixed to the sternites somewhat as in the present-day *Polyxenus*; also it made evident that the coxal ''sockets'' were directed dorsoventrally, rather than ventrally, as I had stated. Since then I have determined that this arrangement of fixed coxae, flanked laterally by spiracles and medially by exsertile–sac pits, holds not only for the taxa which I am including in the *Euphoberiidae*, but also for all representatives of the Archipolypoda.

The discovery of Scudder's ''lost'' types (Burke, 1973: p. 20) in the National Museum of Natural History, since I wrote my first article, has added a wealth of material which will require extensive study. Also requiring exhaustive analysis is the apparently complete English Beale Collection, reported on by Woodward (1887*a*), and acquired by the National Museum of Natural History as part of the Lacoe Collection. When these rare specimens, together with those represented in the collections of other institutions, have been given adequate attention, we should have a comprehensive knowledge of euphoberiid morphology. But until certain material from the Upper Carboniferous of Europe, principally that described by Fritsch (1899), is better known, no firm conclusions can be drawn concerning relationships of Archipolypoda in general. Till then I can offer only brief summaries of characters to establish a new euphoberiid genus and diagnose a new species of that genus, in the hope of clarifying the taxonomy of these forms for other researchers.

For specimens referred to in the text, the following acronyms identify institutions whose catalog numbers are used: BM(NH), British Museum (Natural History); CMNH, Cleveland Museum of Natural History; FM, Field Museum of Natural History; IGS, Institute of Geological Sciences, Leeds; LACM, Los Angeles County Museum; and USNM, National Museum of Natural History.

SYSTEMATIC PALEONTOLOGY

Phylum UNIRAMIA Manton, 1972

Subphylum MYRIAPODA Latreille, 1796

Class DIPLOPODA Gervais, 1844

Order ARCHIPOLYPODA Scudder, 1882

(=Macrosterni, Fritsch, 1899, Paleocoxopleura, Verhoeff, 1928)

Extinct Paleozoic millipedes with free sternites; pleurites fused with tergites. Each of first three anterior segments with tergites and sternites joined characterized by single pair of legs. Terminal segment legless. Tergites with metazonites overlapping prozonites from before backward. Flanks of metazonites spiniferous. Sternites entire or divided medially, two per diplosegment, comprising fixed coxae flanked laterally by spiracles and medially by exsertile–sac pits. Head wider than trunk segments exclusive of spines.

This brief list of characters appears to apply to all American and European Upper Carboniferous forms that I would characterize as archipolypods. But until the European Stephanian millipedes, particularly those described by Fritsch (1899) have been restudied, no reliable summary of the salient characters of the Archipolypoda can be given. While it is certain that representatives of the taxon are millipedes, I feel at present that the group deserves no higher than ordinal ranking, and that its place in present-day classification of diplopods is debatable.

FAMILY EUPHOBERIIDAE SCUDDER, 1882

About two-thirds of body tapers appreciably cauded; cephalad taper gentler, more abrupt in trunk region. Head hypognathous, with mandible, gnathochilarium, teeth, clypeal notch and antennae essentially as in generalized modern millipedes. Eyes, except for strong convexity, resembling those of Recent *Spirobolus*. Collum plate-like, without "hood." First sternite abuts against gnathochilarial structures. Metazonite bears two sets of spines, the laterals and subdorsals, on each flank. Ventrally, tergite joined with two sternites, each entire and bearing a single pair of legs. Sternites overlapping from before backward. Spiracles open in external view, but internal tracheal openings not seen. Tracheal pouches evidently conjoined with sternite. Terminal segment apparently a single ring; in at least one species of *Euphoberia* bearing a slender extension, probably from epiproct, hence properly a telson. Leg composed of six podomeres, here interpreted as coxa, prefemur, femur, postfemur, tibia and tarsus. Trochanter probably fused with prefemur. Femur very elongate. Coxa fixed in sternite. Stout apodemes of *costae coxalis* type traverse femur and prefemur, with spur from prefemur apodeme meeting coxa where angular projection from sternite notches coxa.

Most, if not all of the taxa attributed to this family by Fritsch will probably prove to belong to a distinct family or families of archipolypods. When the Stephanian material is better known it is almost certain that some of the characters listed above will be found to apply to archipolypods in general.

Referred genera: Euphoberia, Meek and Worthen, 1868; *Achantherpestes,* Meek and Worthen, 1868; and *Myriacantherpestes* gen. nov. proposed herein.

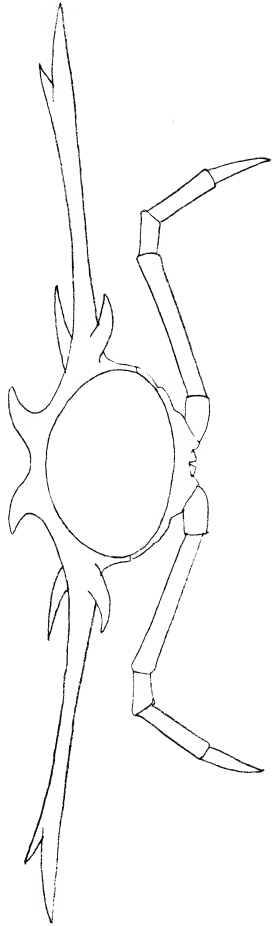

Fig. 1. *Myriacantherpestes hystricosus* (Scudder): restoration of a single diplosomite in posterior view, X 2.

Genus *Myriacantherpestes* gen. nov.

Diagnosis: Like *Euphoberia* and *Acantherpestes* but with much longer lateral spines, each of which shows an additional spinelet, anterior in position, at the base. This anterior spinelet overlaps and interlocks with the posterior spinelet of the preceding diplosomite. Subdorsal spines simple, lacking anterior spinelet found in subdorsals of *Euphoberia;* may be elongate and spike-like, or bent outward and curving laterad or reduced to nodes.

Derivation of name: From the Greek myrios = many + *Ancatherpestes,* the genus.

Type species: Eurypterus? (Arthropleura) ferox Salter, 1863.

Referred species: Myriacantherpestes inequalis (Scudder) n. comb. (USNM 38042A [Scudder, 1890; pp. 424-425, pl. 33, fig. 2] herewith designated lectotype); *Myriacantherpestes hystricosus* (Scudder) n. comb., *Myriacantherpestes clarkorum* (Burke) n. comb., and *Myriacantherpestes bradebirksi* sp. nov. described herein.

Occurrence: Upper Carboniferous, Westphalian B, England; Westphalian C, D, and Stephanian, U.S.A.

Myriacantherpestes ferox (Salter)

Figs. 2*a-f*, 3*a-e*, 4*a-c*, 5*b*

Eurypterus? (Arthropleura), Salter, 1863: pp. 86, 87, fig. 8, p. 84.

Euphoberia ferox, Meek and Worthen, 1868*a*: pp. 26, 27; *Euphoberia ferox* Meek and Worthen, 1868*b*: p. 559; *Euphoberia ferox* Woodward, 1872: p. 174, fig. 63; *Euphoberia ferox,* Woodward, 1873*a*: p. 104, fig. 8; *Euphoberia ferox* Woodward, 1873*b*: p. 1, fig. 8; *Euphoberia ferox,* Scudder, 1882: pp. 157, 158, pl. 12, fig. 23; *Euphoberia ferox* Woodward, 1887*a*: pp. 1–10, pl. 1, figs. 1–8, 11–13; *Euphoberia ferox* Woodward, 1887*b*: pp. 116, 117, figs. 1, 2; *Euphoberia ferox* Scudder, 1890: pp. 208–209, p. 8, fig. 5; *Euphoberia ferox* Kraus, 1974: fig. 3.

Euphoberia ferox of authors (in part).

Acantherpestes Brodiei Scudder, 1882: pp. 156, 157, pl. 11, fig. 5.

Acantherpestes Brodiei Scudder, 1890: pp. 209–210, pl. 9, fig. 23.

Acantherpestes ferox Burke 1973: pp. 14, 20.

Diagnosis: Lateral spines relatively short, posterior borders arcuate, bowing forward moderately. Posterior prong approximately one-half spine length and directed posterolaterally at tip. Anterior prong less than one-third as long as posterior, fairly divergent but not clearly arcuate, with the tip directed an-


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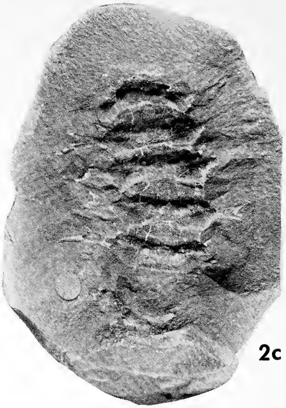
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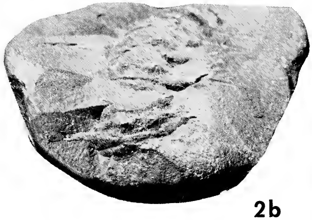
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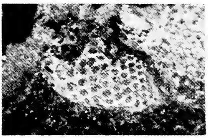
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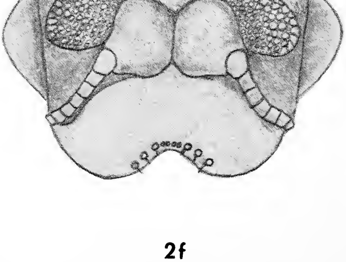
2f

terolaterally. Anterior spinelet well separated from spine base, slightly recurved posteriorly at tip, and approximating the anterior prong in size. Anterior ridge robust. Subdorsal spines thick at base, tapering dorsally and spreading apart, with spike-like tips. Maximum width of diplosomite, including lateral spines, about 3.5 cm. Length, probably about 23 cm. *Holotype:* A specimen in a split concretion, IGS Nos. 12143 and 12144, showing parts of six tergites. Reposited in Paleontological Department, Institute of Geological Sciences, Leeds, England.

Occurrence: Upper Carboniferous, (Westphalian B, *similis-pulchra* Zone) in shale over the Thick Coal at Tipton, North Staffordshire, England.

Remarks: Salter's type shows six tergites. The most posterior of these is separated from the others. As Woodward (1887*a*) notes, the specimen is arched, and posterior portions of the metazonites have been plucked away. These portions, however, are retained in the counterpart impression. In the obverse part, where the tergites show in relief, large portions of the prozonites are exposed—almost the entire surface of the one in the fourth tergite from the anterior. The anterior border of this prozonite is peculiarly angular.

Only the bases of the stout subdorsal spines are showing. They are broken off, but extend dorsally into the matrix of the counterpart, and are probably long and spine-like as in other specimens referable to this species. In this connection it is of interest to note that the anterior ridges of the metazonites are also stout and somewhat reminiscent of those of *Acantherpestes.* Apparently in the *Euphoberiidae* such stout ridges are associated with strong, elongate subdorsal spines. As it turns out, the prominent and characteristic anterior ridges of *Acantherpestes* bear robust subdorsal spines, which tend to slope backward. *Acantherpestes* was not a "flat-backed" millipede, as I had assumed (Burke, 1973: p. 10).

The lateral spines are fairly stout. They bifurcate to form prongs a little beyond midlength of the spine, at which place the posterior prong bends moderately caudad. The anterior prong is about 2½ times shorter than the posterior and bends cephalad at a sharper angle. These lateral spines are subhorizontally disposed, and do not make the sharp angle with the body shown in Woodward's (1887*a*: pl. 1, fig. 11) restoration.

Although Salter (1863: p. 87) reiterated that there were two spines, one in front and one in back, at the base of the lateral spine, and noted that these were

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Fig. 2. (2a–f), *Myriacantherpestes ferox* (Salter): (a) part of concretion containing portions of holotype, IGS 12143, X 1; (b) same, oblique view from base, X 1; (c) counterpart of same concretion, containing portions of holotype, IGS 12144, X 1; (d) part of another concretion showing portion of head figured by Woodward (1887*a*, pl. 1, fig. 3), labrum facing top of page. Note right eye, also gnathal lobe incisor processes in advance of labrum, USNM 256062, X 2; (e) same, right eye, X 6; (f) restoration of head in anterior view. Composite, X 4.

small, he failed to show one set, the posterior, in his illustration (fig. 8, *ibid.*) which is otherwise inaccurate in various respects. Examination of the type specimen, IGS Nos. 12143 and 12144, shows that at least two posterior spinelets are preserved (figs. 2*a*-*e* and 3*a*). Although both sets of spinelets are small, the posterior spinelets are only about half the size of the anterior.

In addition to the Salter holotype, I am illustrating and discussing three more examples of *Myriacantherpestes ferox* which further our knowledge of various regions of the body. One of these, now USNM 256059, was described by Woodward, (1887*a*) who figured the portion contained in one part of a fractured concretion, (his pl. 1, fig. 1), but did not portray the portion shown in the counterpart. This is the only example of *Myriacantherpestes* that I have seen which is identifiable to species and which also shows the proximal and mid-portions of the head in definite association with the body segments—in this case the first eight. Woodward did not note the presence of a mandible, most apparent in the counterpart (fig. 3*c*) where it splays out laterally and indents the second body segment. However, it also shows as a lateral border in the obverse view of the head and evidently is also represented by traces in advance of the labrum.

The eyes of this specimen are somewhat obscure. Woodward does not describe them, but describes those of another head, USNM 256062 (his pl. 1, fig. 3; my figs. 2*d*-*e*) as follows: "There are about ten rows of facets in each eye . . . and seven or eight facets in each row; the smallest facets being those nearest the centre of the head, and the largest toward the border." It is surprising that he did not also note the spiral arrangement of the lenses, distinct from that of the rows, which immediately becomes apparent when an attempt is made to distinguish the rows. The statement concerning the relative sizes of the lenses seems to hold for all eyes of the species that I have examined, including the specimen USNM 256059, which shows the eight segments. The eyes of *Myriacantherpestes ferox,* and in fact those of all specimens of euphoberiids in which the eyes are recognizable, bear a marked resemblance to those of the recent genus *Spirobolus.* I shall consider this further in the discussion that follows.

In the head of USNM 256059, on both part and counterpart, what appears to be a matrix-filled clypeal notch is directed toward the left eye. In this specimen, also on the left side, two antennomeres are shown; the first arises from the antennal socket and is large and rounded. The second appears somewhat flattened and is directed ventrally. On the counterpart a portion of it appears to have broken off in the socket, which extends through to the external side, apparently in the direction of the genal notch. The socket and eye of the right side are not preserved in the counterpart; in the obverse there is a trace of the first antennomere. In USNM 256062, the base of the antennal socket of the right side is large with broadly rounded walls; it is large and round on the left side as well. Neither shows traces of antennomeres. Two gnathal lobe incisor processes extend beyond the head. This specimen is contained in two parts of a fractured concretion. The other part shows portions of the gnathal lobes from which the incisor processes have broken away. Woodward (1887*a*: p. 10 caption, pl. 1, fig. 3) identifies these as antennae.

Woodward's figure of the eight segments shows an impression of the external surface viewed from the inner side, except for the lateral spines of the left side, which stand out in relief, and also the bases of the subdorsal spines, which are directed dorsally into the matrix; in addition there are extensions of the metazonites. In effect, the counterpart exhibits these same structures in reverse. Posterior to the first two, the segments have slipped apart, carrying in this concave impression the overlapping portions of the metazonites with them and leaving the prozonites of the counterpart exposed. Most of the first segment is concealed, but the second shows no trace of subdorsal spines. These spines are mere nodes in the third and apparently somewhat nodose in the fourth as well. The height of the spines of the remaining segments is not determinable. Only the lateral spines of the left side are preserved. The anterior prong of the first lateral spine is not apparent. The posterior prong is slender and attenuate. The posterior prong of the second is more robust, but the anterior prong is a mere vestige. The prongs of the third spine are not preserved. Apparently the prongs of the remaining spines are normal. The relatively long anterior spinelets of the two posterior segments are present in the spines of the part illustrated by Woodward, and an impression of the small posterior spinelet shows in the second of these; in the third segment from the posterior, the tip of this spinelet, plus an impression of the rest can be seen. In the counterpart, the entire spinelet of the second posterior segment is preserved. This spinelet is represented by an impression in the third segment from the posterior.

The last three segments have slipped an appreciable distance to the left, and have apparently torn away from the underlying sternites, but none of the sternite structures can be seen.

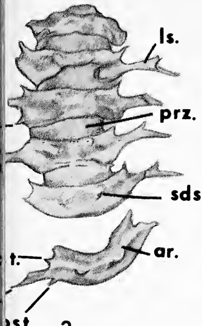
A specimen described by Woodward (1887*a*: pl. 1, fig. 4) now BM(NH) I 1050 is of particular interest because he based on it his restoration of the legs, sternal region, and probably in great part the subdorsal spines. It is contained in two portions of a fractured concretion; that portion showing most of the specimen is illustrated in my fig. 3*d*. As I have already noted (Burke, 1973: p. 11), Woodward's orientation is faulty; the end showing several of the elongate subdorsal spines is anterior, and I have shown it so disposed in my illustration. Woodward is correct in saying that there are 17 diplosomites. There is, however, little to indicate which part of the body is represented. A subdorsal spine of the fifth tergite from the base of the figure measures 8.3 mm, while one of the 16th tergite is 6.5 mm in length; this decrease in height might indicate that a portion of this string of diplosomites extends somewhat anterior to the midlength. In Woodward's illustration the spine shown on the second tergite from the posterior end is inaccurately drawn and is very misleading. It is actually a broken lateral spine that shows a tiny posterior spinelet at the base. There are also broken lateral spines on the tergite preceding it and the two following it. There is another little posterior spinelet at the base of the 15th lateral spine on the left side. The 11th and 12th diplosegments illustrate metazonite-prozonite overlap very well. Portions of the fourth and fifth diplosomites have spalled away, exposing the underlying prozonites.

In part, this is an internal view of the sternal region. The legs seen on the left side are flattened, and it is difficult to distinguish the podomeres. The sternites in that area have been ripped away, and the portion of the counterpart that should contain them, and parts of the legs, was apparently broken off when the specimen was found. Even so, the legs were damaged, probably at the time of the burial of the specimen. They are arched downward and the proximal openings of the prefemurs on that side are crushed in. Fracture extends even to the median area, so that Woodward's depiction of the sternites, particularly of the exsertile-sac pits (pl. 1, fig. 5) is mostly diagrammatic. The figure is also oriented in reverse.

The dense clayey mineral that probably represents degraded phosphate derived from the original cuticle of the skeleton preserves no details of the apodeme structure. However, careful excavation and removal of this material from the interiors of the legs of the right side reveals impressions of various structures. The impressions represent traces of the prefemur apodeme and associated features of the coxa and sternite, all severely crushed and distorted.

Woodward (1887*a*: p. 9, pl. 1, fig. 8) describes as a pygidium or telson what turns out to be the last two spine-bearing segments. Referring to this specimen in my earlier article, I had (Burke, 1973: p. 14) suggested that the last (posterior) segment might be the telson and the anterior the metazonite of the penultimate segment, with the spines directed posteriorly because of breakage. It turns out that as the lateral spines of *Myriacantherpestes* approach the caudal extremity they tend to be directed backward, until the two spines of the last spine-bearing segment are subparallel or parallel. Woodward's specimen (now USNM 256060), therefore, consists of the last two spine-bearing segments.

Fig. 3. *Myriacantherpestes ferox* (Salter): (a) sketch of portion of specimen, IGS 12143, upon which Salter's (1868, fig. 8) illustration was based. Note posterior spinelets (pst.), X 1; (b) portion of specimen, NMNH 256059 upon which Woodward's illustration (1887*a*, pl. 1, fig. 1) was based, X 1; (c) counterpart of the same, X 1; (d) portion of specimen, BM(NH) I 1050 which Woodward illustrated (1887*a*, pl. 1, Fig. 4), X 1; (e) sketch of ten terminal spined diplosegments after Kraus (1974, fig. 3), X 1.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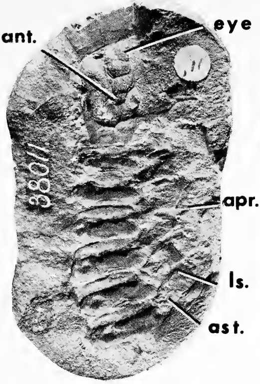
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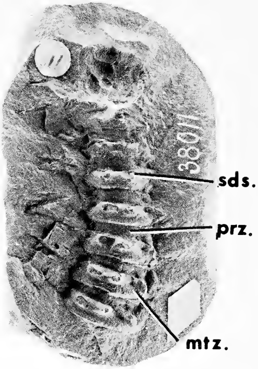
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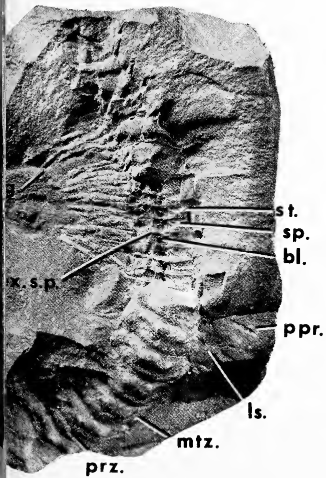
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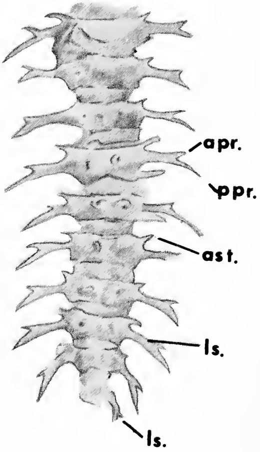
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The epiproct is either missing or concealed in the matrix below. Two examples of *Myriacantherpestes hystricosus* (Scudder), CMNH 3725 and LACM A.5976, show a terminal structure reminiscent of the epiproct figured by Hoffman (1969: p. R580, fig. 306–3). In LACM A.5976, crude preparation has exposed the interior of this segment; the walls resemble those of an epiproct ring. In these specimens the spines of the last spine-bearing segment diverge slightly and the anterior prong appears to be lacking. The spine of the preceding segment is inclined caudad as in Woodward's specimen.

Kraus (1974: fig. 3) illustrates an exceptional example of *Myriacantherpestes ferox,* which, although very much crushed, preserves a portion of the terminal spine-bearing segment and nine segments preceding it. My fig. 3*e* is sketched from the Kraus figure. The last spine-bearing segment is represented by the spine of the right side, which was apparently longer than shown in the Kraus figure; his photograph appears to have been cropped short. In any case, enough of it remains to demonstrate that it must have extended nearly parallel to the opposite spine. The anterior prong is not shown, and the epiproct is not evident. The spines of the preceding segment swing caudad, as in the Woodward specimen; both the anterior and posterior prongs are preserved.

Myriacantherpestes bradebirksi sp. nov.

Euphoberia (possibly a new species)?, Woodward, 1872: pp. 9, 10, pl. 1, fig. 9.

Euphoberia ferox, Gill 1924: pp. 457–459, text fig. 1. *Euphoberia ferox* Brade-Birks 1928: pp. 400–406, pl. 16, text figs. 1–3.

Acantherpestes sp., Burke, 1973: pp. 11, 20.

Diagnosis: Differs from *M. ferox* in size (maximum width, including lateral spines, 28.6 mm) and in having the posterior border of lateral spine only slightly bowed forward; spine also relatively more robust and rounded, tapering almost uniformly from base to tip of the posterior prong, except where the anterior prong originates. Anterior prong not sharply divergent from posterior prong. Anterior spinelet not widely separated from spine base.

Derivation of name: The species is named for the Rev. Canon S. G. Brade-Birks, veteran authority on millipedes, fossil and recent.

Type material: Holotype, BM(NH) I 61176, a chain of nine diplosegments in loose articulation and variously preserved. Paratype, BM(NH) I 41497, a broken or poorly articulated string of 25 diplosegments, also variously preserved.

Occurrence: Upper Carboniferous. (Westphalian B, *similis-pulchra* Zone) in the Crow Coal, Crawcrook, Durham, England.

Referred specimen: USNM 256061, a string of 13 diplosomites, variously preserved; some loosely articulated, in part and counterpart of a concretion. *Remarks:* This species has been thoroughly described by Gill (1924) and Brade-Birks (1928). It is much smaller than *Myriacantherpestes ferox* and, as my diagnosis indicates, shows a characteristic lateral spine that differs sharply from that of *M. ferox.* The lateral spinelets and subdorsal spines, however, resemble those of the latter species.

Woodward (1887*a*: pl. 1, fig. 9) figured, but except for passing notice, did not describe USNM 256061, which I refer to *Myriacantherpestes bradebirksi*. The portion of the specimen figured by Woodward is contained in one part of the concretion. Woodward did not orient his specimen correctly; he showed the anterior end directed toward the foot of the page.

Woodward notes (1887*a*: p. 10, caption, fig. 9) that USNM 256061 consists of ''12 connected somites. . . .'' Actually there are remnants of an additional ''somite'' at the anterior end. The lateral spines agree with my diagnosis to the extent that the length of the posterior prong is considerably in excess of that of the anterior and neither prong shows much curvature. However, the length of the posterior prong is much less than that noted in the types—as little as half the length in some instances. The anterior spinelets are about the same relative length as in *M. ferox*. There appear to be traces of very small posterior spinelets on the fifth and sixth diplosegments of the left side.

This specimen is of the greatest interest because it shows the length of the subdorsal spine, which is apparently not determinable in the Brade-Birks and Gill type specimens. The spine is indicated on the right side of the last two diplosomites of the posterior end of the string. On the next to the last of these, on the counterpart not figured by Woodward, the spine is nearly complete. It was erect, elongate, and possibly a little more slender than the subdorsal of *Myriacantherpestes ferox.* I feel reasonably certain that NMNH 256061 is properly referred to as *M. bradebirksi,* and that this type of subdorsal spine will be found to characterize more typical examples of the species.

Discussion

A restoration of the head of *Myriacantherpestes ferox* in anterior aspect is shown in fig. 2*f*. I cannot claim that it is a reliable representation. Usually when a concretion containing the head of a specimen of *Myriacantherpestes* is fractured, the external portion of the anterior surface does not break free; it is represented by a mold or at best a partial cast which is not necessarily fully indicative of the external surface. Woodward's (1887*a*) illustrations of heads of *M. ferox,* which are now in the USNM Lacoe Collection, were derived from impressions of the exteriors of the heads. All show evidence of compaction or crushing. On the other hand, I have been able to supplement these with photographs of two BM(NH) specimens which appear to show at least some of the outer surface in anterior aspect and do not appear to have undergone severe crushing.

As fig. 2*f* shows, with some correction to compensate for crushing, addition of the robust mandibles and a stronger incurvature of the dorsal border—all of which are indicated by the BM(NH) photographs—the general appearance of the head is fairly similar to that of most recent millipedes.

The overall surface is rugose, markedly so in the dorsal portion. There are definite angular depressions in the region of the genae. In restoring the antennae, I have placed them in these depressions. Except for two, or at best three, rather stout proximal antennomeres, the antennae of *Myriacantherpestes* are unknown. I am restoring them as stout, somewhat flattened, and capable of being recessed. In both *Euphoberia* and *Acantherpestes* the antennae are more rounded and fairly slender.

The dorsal half of the head shows strongly bulbous areas flanking the epicranial suture. These are external manifestations of the adductor mandibulae muscles, which attach to the median septum and areas adjacent to it. They are delimited from other parts of the head by what Woodward termed ''grooves''; possibly septa would be the better term. The inflated areas diverge ventrally in the form of a broad V at the termination of the epicranial suture, curve laterally in advance of the eyes and then swing dorsally toward the antennal sockets which extend slightly ventral to them and intervene between them and the eyes. The eyes are placed laterally and, except where they are exposed ventrally on the lateral sides of the antennal sockets, are delimited from the other head structures by grooves or septa. Although they are not as bulbous as the inflated areas adjacent to the epicranial suture, they are nevertheless quite definitely convex.

Except for this covexity of the entire surface, which is not characteristic of *Spirobolus*, there are some striking similarities between the eyes of *M. ferox* and those of *Spirobolus*. For example, the lens patterns of *M. ferox* described by Woodward (1887*a*: p. 7) and also illustrated in figs. 2*d* and *e* are quite similar. In their external aspects, the individual lenses of *Spirobolus* are convex; as far I can determine, they were convex in *Myriacantherpestes ferox* also. Viewed from the inside, the lens processes of *Spirobolus* are much more drawn out and rod-like than those of *Julus*, and more widely separated from each other. The lens processes of *M. ferox*, although they have undergone mineral replacement, appear to have been similar to those of *Spirobolus*. The interpretations of the eyes of *Spirobolus* as ''simple aggregate'' may be based on the assumption that they show essentially the same structure as those of *Julus*, but I am convinced that whatever the ultimate structures of these organs

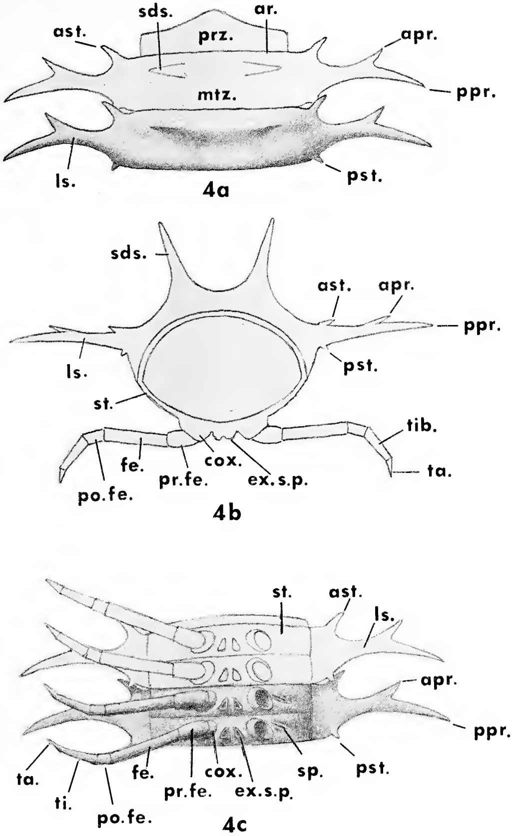

Fig. 4. Restorations of diplosomites of *Myriacantherpestes ferox* (Salter): (a) dorsal view; (b) posterior view and (c) vzntral view, all X 3.

in both *Spirobolus and Myriacantherpestes* prove to be, they will be demonstrably more complex than those of *Julus*.

Restorations of diplosomites of *Myriacantherpestes ferox* in dorsal, posterior and ventral views, with pertinent structures labeled, are shown in figs. 4*a*, 4*b*, and 4*c*. It is obvious, considering the height and prominence of the subdorsal spines, that we are not dealing with a "flat-backed" millipede with *M. ferox*, and neither apparently was Gill (1924, p. 459) who used this term in reference to *M. bradebirksi*. The subdorsal spines of Gill's specimen are evidently broken off at the bases. Probably in these English species the subdorsal spines functioned for the most part as a means of defense—much as did those of *Euphoberia*.

But the lateral spines and spinelets of these English taxa, and all other species of *Myriacantherpestes* as well, contrast sharply with those of *Euphoberia* and *Acantherpestes*. Neither of the latter genera display the elongate lateral spine of *Myriacantherpestes,* which in all species of the genus spreads widely enough to have covered and protected the legs. Except for *M. hystricosus,* in which this spine has undergone considerable modification, all show the characteristic anterior and posterior prongs. In *Euphoberia* and *Acantherpestes* the posterior spinelet is relatively prominent; in *Myriacantherpestes ferox* and *M. bradebirksi* it is very small, and even in the American species, where the anterior and posterior spinelets approach each other in size, the posterior spinelet is the smaller of the two. However, the major difference between *Myriacantherpestes* and the other two euphoberid genera lies in the total absence of the anterior spinelet in the latter two taxa.

Small as these spines are in the two English species, they appear to function much as they do in the geologically younger American representatives of *Myriacantherpestes*. The posterior spinelet overlaps the anterior and the two can become interlocked, thus giving rigidity to successive diplosomites. As Manton (1954, 1961, *et. seq.*) has indicated, such rigidity enhances the pushing power of millipedes, and some modern millipedes when searching for food drive their heads into matted masses of leaves, force them apart and penetrate them by drawing in the legs and pushing upward and forward. I have already noted (Burke, 1973) that *Myriacantherpestes clarkorum* and *M. inequalis,* in which the subdorsal spines were much reduced, had possibly acquired this functional characteristic. It seems likely that these two English species of *Myriacantherpestes* might also have been capable of penetrating between leaf masses to some extent. As I have pointed out in reference to USNM 256059, the subdorsal spines of the first four segments are either wanting or much reduced; the head and body could have been inserted as far as the fourth segment at least.

In American species of *Myriacantherpestes,* the spinelets are quite prominent, and their interlocking must have been a definite functional requirement for performance of what Manton terms the "bulldozing" technique of penetration of leaf masses. The spinelets probably severely limited lateral flexibility of

Myriacantherpestes. Without the anterior spinelet, and unhampered by such restrictions, *Euphoberia* and *Acantherpestes* were more flexible, and as some specimens of *Euphoberia* demonstrate, representatives of that genus could, as a matter of fact, coil laterally in a spiral.

For comparison with *Myriacantherpestes ferox,* fig. 1 shows a restoration of a diplosomite of *Myriacantherpestes hystricosus* (Scudder) in posterior view. The extremely elongate lateral spines and the outcurving subdorsals illustrate clearly that this species was singularly well adapted for the ''bulldozer'' role.

A restoration of the dorsal surface of a complete specimen of *Myriacantherpestes ferox* is shown in fig. 5*a*. The scale is about one-half natural size. The number of segments (45 exclusive of the head) is based on estimates of the number of segments present in *M. hystricosus;* I have seen no representatives of *M. ferox* complete enough to justify such an estimate. For that matter, no complete specimens of *M. hystricosus* are known either, but material available is sufficient to make a fairly reliable estimate at some essentially mature stage. Considering that the segments were probably added even at late moults, the exact number is not of much consequence. About all that can be claimed for this restoration is that it gives some idea of the overall proportions of the body. The terminal regions are shown, and, to the extent possible in a limited space, so are the bewildering numbers of bristling spines that characterized this animal.

Scudder (1882: p. 147) regarded the spines of his Archipolypoda as the ''least important, structurally considered'' features distinguishing representatives of that taxon from modern Diplopoda. Although he regarded spines as defense armament, the possibility that they might have had some other functional value does not seem to have occurred to him. Spines undoubtedly functioned to some extent for defense in *Myriacantherpestes* and *Acantherpestes,* but they do not seem to have served any other purpose in the various species of *Euphoberia*. The evidence supports the theory that in *Myriacantherpestes ferox* we are witnessing the transformation from an armored diplopod, somewhat similar to *Euphoberia,* to a ''flat-backed'' form like *M. hystricosus,* admirably adapted to function as a ''bulldozer.'' Thus, the generic separation of *Myriacantherpestes* on the basis of spine structure appears to be justified.

I am currently forced to employ spine specialization as practically the only basis for taxonomic distinction among the Archipolypoda. The spines of *Acantherpestes,* despite various resemblances to those of *Euphoberia,* are specialized after their own fashion; *Acantherpestes major* is not a giant *Euphoberia,* and *Acantherpestes horridus* (n. comb), though originally attributed to the latter genus by Scudder (1882), is easily distinguishable from various species of *Euphoberia* also. The lateral spines of *Acantherpestes* are extremely variable; some, such as those of the tergite illustrated in fig. 5*a*, resemble those of *Euphoberia,* but others (and on the same specimen) have the

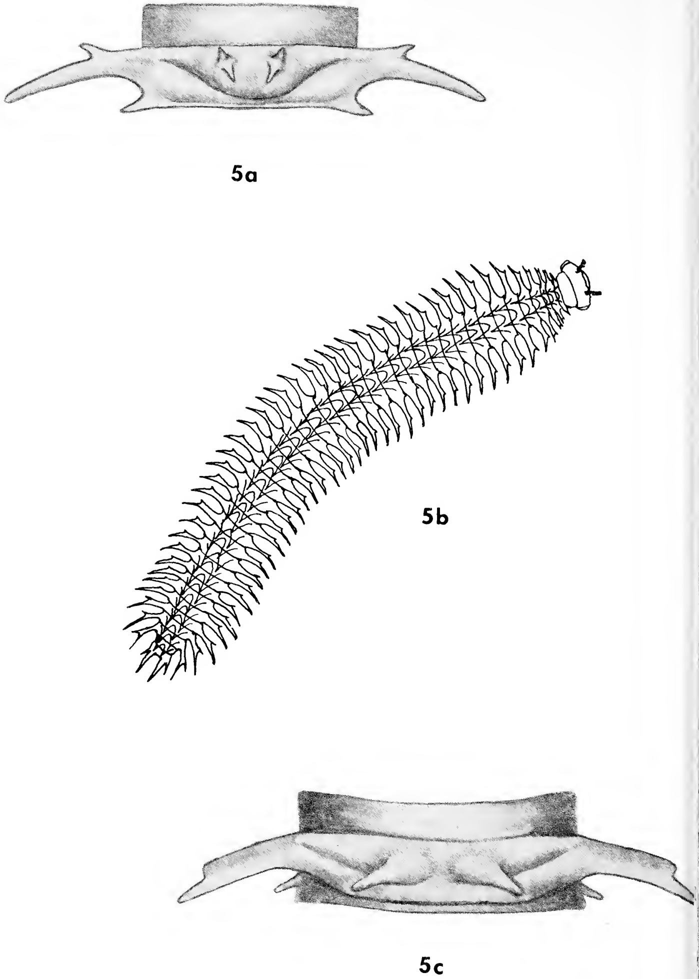

Fig. 5. (a) restoration of tergite of *Euphoberia armigera* Meek and Worthen in dorsal view. Composite, X 5; (b) restoration of entire animal, *Myriacantherpestes ferox* (Salter) in dorsal view. Composite, X ½; (c) sketch of tergite of *Acantherpestes horridus* (Scudder), FM PE24621, in dorsal view, X 5.

peculiar "boot-shape" noted by Scudder (1890: p. 425, pl. 33, fig. 4). Scudder, incidentally, mistook those spines for subdorsals. Both varieties are illustrated in Scudder's figure of *Acantherpestes horridus* (1882: pl. 13, fig. 11). As in *Euphoberia,* the anterior prong is short, but it is also more variable in *Acantherpestes* and may even be slightly recurved. There is a tendency in *Acantherpestes* for the lateral spine base to be directed posterolaterally. A surprising feature of *A. horridus*, shown in fig. 11 cited above, is the presence of two posterior spinelets on some metazonites. I have not verified this by examining Scudder's specimen, but there is evidence of two posterior spinelets on one of the metazonites of USNM 38042B, which I take to be a specimen of *Acantherpestes major.* This is the specimen with the "boot-shaped" lateral spines, noted by Scudder (1890). I do not recall finding multiple posterior spinelets on any other archipolypod.

A very characteristic feature of the tergite of *Acantherpestes* is illustrated in the original figure of the holotype of *Acantherpestes* (Meek and Worthen, 1868*b*: p. 538). This is the attenuated anterior ridge, which expands as it extends mediad from either side, and which carries the stout subdorsal spines. In FM PE 24621, the tergites of which are the basis for the restoration shown in fig. 5*a*, the anterior ridge is very swollen and elevated in the region where the subdorsal spines originate. The spines are quite distinctive. They are nearly as long as the laterals and are broad at their inception, tapering upward to terminate in fairly sharp tips. From the base they spread apart in their course and bend caudad.

The backwardly directed, or even, as evidenced in some of the laterals, foreshortened spines of *Acantherpestes* contrast strongly with those of *Myriacantherpestes* and even with those of *Euphoberia.* Such spines evidently would have been of little assistance in burrowing. Possibly they were in the process of reduction. Nevertheless, having spines of this type, *Acantherpestes* could have edged into, or even to some extent, penetrated niches or crevices inaccessible to other archipolypods of comparable size. One specimen of *Acantherpestes major,* FM PE25432, shows the anterior region fairly well. The body narrows somewhat abruptly posterior to the trunk region, in the direction of the head, of which enough is preserved to indicate that it was relatively small.

Taken all together, if the specialized structures of *Acantherpestes* suggest any one thing, it is the possibility that these animals might have been carnivorous millipedes. Since the Archipolypoda appear to have had excellent vision, as millipedes go, it would not be surprising if one of the line became an active predator.

In fig. 5*b*, the restored tergite of a "typical" *Euphoberia* is shown—in this case, *Euphoberia armigera.* The lateral spines are not especially prominent. The base arises nearly at a right angle to the longitudinal axis of the tergite.

There is no anterior spinelet. The anterior prong appears aborted, and the posterior prong is similar to that of *Myriacantherpestes*. It is fairly well developed and curves posterolaterally. There is a single subdorsal spine, not especially prominent, on each side of the midline. Each is slightly bowed and bends caudad slightly. At the base of the subdorsal there arises a short anterior spinelet.

Euphoberia armigera apparently bears the full complement of spines found in that genus. Species of this taxon do not seem to show an anterior spinelet or accessory posterior spinelets. On the other hand, whether as a result of random variation, or as a consequence of true specific differentiation, some specimens seemingly attributable to *Euphoberia* appear to show little more in the way of armament than simple lateral and subdorsal spines. Whatever the case, the genus as a whole does not approach either *Myriacantherpestes* or *Acantherpestes* in specialization, and may very well represent the spiny armored stem stock from which those two genera took origin.

Because of damage resulting from compaction and crushing, together with degradation of the minerals which replaced the original cuticle of which they were composed, determination of structures associated with the coxae, telopodites and sternites of archipolypods is extremely difficult. Since I am unable presently to determine these features in sufficient detail, I will not attempt to delineate them here, but will only offer the following broad interpretations which may be faulty in some details.

The coxa is quite evidently fixed to the sternite quite similar to the way it is in the Recent *Polyxenus*. Also, as in that genus, skeletal ridges run lengthwise along the proximal podomeres; they are indicated by extensive *costae coxales* structures on the anterolateral sides of both prefemur and femur. However, I find no structures indicative of the Y-skeleton of *Polyxenus*. Within these podomeres, in contrast to the leg structure of *Polyxenus*, the skeletal ridges are represented by strong apodemes, undoubtedly connected by elastic arthrodial membrane at the juncture of these two leg joints. At the anterior terminus of the prefemur, a spur from its apodeme contacts an arrow-shaped ridge on the inner wall of the coxa, to which it was apparently also attached by arthrodial membrane. In addition, the tip of the spur seems to have extended even to what amounted to an inner arm of the tracheal pouch and to which it was evidently attached in a similar manner.

In the few specimens that I have seen in which the coxa is shown in external view, the spiracle flanks it closely on the lateral side, and the spiracle is open, indicating a respiratory function. The opening leads into a hollow canal, which obviously must be the tracheal pouch, but on the inner side it is difficult to trace. It appears to intervene between the coxa and the sternite anteriorly, and as the inner arm of the pouch, must have served for attachment of some of the powerful muscles associated with the apodemes of the prefemur and femur. I have found no evidence of foramina for tracheal exits.

The apodeme structure is present in the legs of all the euphoberid genera. It was certainly not related to size, for it is as well developed in *Euphoberia* as in large species of *Acantherpestes* and *Myriacantherpestes*. Fusion of the tergites with the pleurites, presence of free sternites, and also this particular type of leg construction all contributed to produce a simplicity of structures of the ventral side of these animals.

The leg muscalature may have originally contributed to speed in running, which, together with well developed spines, would have enabled these animals to escape or fend off predators. Even the species of *Myriacantherpestes* which utilized leg muscles in the "bulldozing" technique still possessed ample spines which, although specialized for that purpose, would have nevertheless discouraged predators. In addition, their great size was a further advantage against most carnivorous animals of their time.

Given the spiny armament, however, most representatives of the *Euphoberidae* could not have been adept at burrowing, and probably fed from loose-packed litter, slightly compacted soil, or soft mold that had accumulated within hollow logs. As I have suggested, *Acantherpestes* might even have been a carnivore. Only *Myriacantherpestes* and *Arthropleura* succeeded in penetrating compacted masses of leaves and obtained food which was otherwise available only to burrowers.

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I am greatly indebted to numerous individuals and institutions for aid in my studies of the Archipolypoda. I can list here only those contributing directly to the present paper. These include Dr. Winnifrede C. Randall, formerly of Case Western Reserve University, who shared with me her extensive knowledge of the Uniramia. For loaning specimens for comparison and study, I am grateful to the following representatives of various repositories: Drs. H. W. Ball and S. F. Morris of the British Museum (Natural History); Dr. E. S. Richardson, Jr. of the Field Museum of Natural History; Dr. W. H. C. Ramsbottom of the Institute of Geological Sciences; Dr. Bernhard Kummel and Miss Vickie Kohler of the Harvard Museum of Comparative Zoology; Dr. E. C. Wilson of the Los Angeles County Museum; and Drs. Porter Kier, Richard Grant, and Frederick Collier of the National Museum of Natural History. A persistent gadfly, Dr. Ellis L. Yochelson of the United States Geological Survey, aided and encouraged me to finish the work. Dr. W. D. Ian Rolfe of the Hunterian Museum, University of Glasgow, has read and reviewed the manuscript at various stages

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References

Brade-Birks, S. G., 1928, An important specimen of *Euphoberia ferox* from the Middle Coal Measures of Crawcrook, Geol. Mag. **65**: 400–406.

Burke, J. J., 1973, Notes on the morphology of *Acantherpestes* (Myriapoda, Archipolypoda) with the description of a new species from the Pennsylvanian of West Virginia, Kirtlandia **17**: 1–24.

Fritsch (Frič), A., 1899, Fauna der Gaskohle und der Kalksteine der Permformation Böhmens, **4** (Praha).

Gill, E. L., 1924, Fossil arthropods from the Tyne Coalfield, Geol. Mag. **61**: 455–471.

Hoffman, R. L., 1969, Myriapoda, exclusive of Insecta, *in* R. C. Moore, ed. Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, **2**: 572–606.

Kraus, O., 1974, On the morphology of Paleozoic diplopods, *in* J. G. Blower, ed. Myriapoda, Symposia Zool. Soc., London **32**: 13–22, Academic Press, London.

Manton, S. M., 1954, The evolution of arthropodan locomotory mechanisms, Pt. 4. The structure, habits and evolution of the Diplopoda, Jour. Linn. Soc. (Zool.) **42**: 299–368.

———1956, The evolution of arthropodan locomotory mechanisms, Part 5. The structure, habits and evolution of the Pselaphognatha (Diplopoda), Jour. Linn. Soc. (Zool.) **43**: 153–187.

———1958, The evolution of arthropodan locomotory mechanisms, Part 6. Habits and evolution of the Lysiopetaloidea (Diplopoda), some principles of the leg design in Diplopoda and Chilopoda, and limb structure in Diplopoda, Jour. Linn. Soc. (Zool.) **43**: 487–556.

———1961, The evolution of arthropodan locomotory mechanisms, Pt. 7. Functional requirements and body design in Colobognatha (Diplopoda), together with a comparative account of diplopod burrowing techniques, trunk musculature and segmentation, Jour. Linn. Soc. (Zool.) **44**: 383–461.

Meek, F. B. and A. H. Worthen, 1868*a*, Preliminary notice of a scorpion, a *Eurypterus?* and other fossils, from the Coal Measures of Illinois, Am. Jour. Sci. 2nd. Ser. **46**: 19–28.

———1868*b*, Articulate fossils of the Coal Measures, Illinois Geol. Surv. Bull. **3**(2): 540–572.

Salter, J. W., 1863, On some species of *Eurypterus* and allied forms, Quart. Jour. Geol. Soc. London **19**: 1–87.

Scudder, S. H., 1882, Archipolypoda, a subordinal type of spined myriapods from the Carboniferous formation, Boston Soc. Nat. History Mem. **3**: 143–182.

———1885, Myriopoda, *in* Zittel, K. A. Handbuch der Paleontologie, **2** (1) 721–731, Munchen and Leipzig.

———1890*a*, New Carboniferous Myriapoda from Illinois, Boston Soc. Nat. History Mem. **4**: 417–442.

———1890*b*, The Fossil Insects of North America **1**: 1–455, New York.

Verhoeff, K. W., 1926–32, "Diplopoda" *in* H. G. Bronn, Klassen und Ordnungen des Tierreichs, Leipzig Acad. Verlag. **5**(2): 1–2084.

Woodward, H., 1866–78, A monograph of the British fossil Crustacea belonging to the Order Merostomata, Palaeontographical Soc. (Monogr.) 1–263.

———1873*a*, On some supposed fossil remains of Arachnida (?) and Myriopoda from the English Coal Measures, Geol. Mag. **10**: 104–112.

———1873*b*, On British fossil Arthropoda, Separate, 1–9, London (not seen).

———1887*a*, On some spined myriapods from the Carboniferous Series of England, Geol. Mag. **24**: 1–10.

———1887*b*, Supplementary note on *Euphoberia ferox* Salter, Geol. Mag. **24**: 116–117.

Key to Abbreviations Used to Designate Structures in Illustrations

ant.	antenna
apr.	anterior prong of lateral spine
ar.	anterior ridge
ast.	anterior spinelet
bl.	base of leg
cox.	coxa
ex.s.p.	exsertile-sac pits
fe.	femur
lf.	lateral furrow
lg.	leg
ls.	lateral spine
mnd.	mandible
mtz.	metazonite
pl.	posterior lobe
po.fe.	postfemur
ppr.	posterior prong of lateral spine
pr.	posterior ridge
pr.fe.	prefemur
prz.	prozonite
pst.	posterior spinelet
sds.	subdorsal spine
sp.	spiracle
st.	sternite
ta.	tarsus
ti.	tibia

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HABITAT PREFERENCE AND UTILIZATION BY THE EASTERN CHIPMUNK (*TAMIAS STRIATUS*)

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Abstract

Chipmunks in study areas in southeastern Ohio occupy a wide range of vegetational situations, but highest densities and stable populations are found in forests that are in latter stages of succession and are characterized by mature trees, dense canopy, and sparse summer herbaceous vegetation. Sectors uninhabited by chipmunks are typified by dense growth of young trees and shrubs or sandy soil. Structural aspects of the soil and food availability affect burrow site selection and population structure. The role of dense ground cover as noise in the social communication channel is interpreted as a selective force in habitat selection.

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Introduction

The presence and abundance of a population in any given locality and the spatial distribution of individuals within that population are dependent upon the spatial and temporal allocation of the resources that are necessary for survival and reproduction of the individuals of the population. Some resources are limiting to a natural population in subtle ways, but other resources exert controls on populations in overt ways that can be quantified. The eastern chipmunk (*Tamias striatus*) occurs throughout the eastern United States and Canada in suitable habitat (Hall and Kelson 1959). Suitable habitat for this chipmunk includes a wide range of brushland and open forests (Forbes 1966). Population estimates of 1 to 39 individuals/ha are reported with 10 individuals/ha as an average density. The home range of the eastern chipmunk is usually less than 0.5 ha. The center of activity is a burrow system. The chipmunk hibernates from October to March. The burrow serves as a retreat from the elements, predators, and conspecifics, as well as a nursery and a hibernaculum. The availability of suitable sites for burrows thus constitutes a major resource upon which survival is determined and about which various factors can be measured.

The present study is concerned with the habitat utilization of the eastern chipmunk in southeastern Ohio, relating vegetational, topographic, and physiographic features to burrow sites and correlating these factors to chipmunk density and population structure.

Methods

The field study was conducted on three populations of chipmunks in Athens County, Ohio, during 1974. Population A inhabited a partially disturbed woodlot (Area I) approximately 5 ha in area, which is bordered on three sides by pasture and fields (Fig. 1). Three small streams traverse the woodlot. Population B occupied a wooded, rock-outcrop hillside (Area II) with a westerly exposure. Population C resided in a woodlot also containing a rock-outcrop, but the relief is less steep (Area III). Areas I and II were chosen because they contained a variety of vegetative, topographic, and physiographic features and varying degrees of man-made disturbances and uninhabited habitats. Area III was selected later as a comparison to Area II.

Chipmunks were live-trapped at known burrow systems with National live-traps. Individuals were sexed, categorized as to adult or juvenile, weighed, assessed as to reproductive condition, and marked with #1 ear tags (National

Band and Tag Co.) and fur dye (Nyanzol D) to facilitate field identification and burrow use.

Information about the age and sex of individuals occupying specific burrows, the slope in the immediate vicinity of the burrow entrance, the angle of exposure of the burrow site, and the proximity of the burrow entrance to solid objects was recorded on all burrows identified as occupied by specific individuals. Proximity to herbaceous and woody vegetation, the distance to man-induced disturbance at the burrow site, distance to water, position on a slope, amount of ground cover, drainage, and the number of burrow entrances within a 3-m radius of the main burrow entrance were also quantified for the most frequently utilized burrows at Areas I and II. Analysis of the vegetation at places with active burrows as well as at randomly selected points in unoccupied habitat was accomplished using 15-m transects at the 4 major points of the compass originating at a burrow site or a randomly selected point. Relative density, relative dominance, relative frequency, and importance values of woody and herbaceous species were calculated (Cox 1967). Percent canopy cover was estimated along line transects using the method of James and Shugart (1970).

Analysis of chipmunk densities and population structure were conducted from early June to September, after the dispersal of young of the spring litter. Population A was live-trapped continuously over this period, and all residents were identified. Population B was live-trapped over two, two-week intervals, and density was estimated by field observation of marked and unmarked animals.

Results

Area I can be divided into a sector high in chipmunk and burrow site densities and a sector in which chipmunks were not sighted and burrow sites were not found (Fig. 1). Area II also contained sectors in which chipmunks were either present or absent. Vegetative parameters were measured at 25 active burrow sites and 20 random points in unoccupied parts of the two areas. Two variables, total density of woody species and percent ground cover, are significantly different between the two areas (Table 1). There are no significant differences between inhabited and uninhabited sectors for values of relative dominance, relative density, relative frequency and importance values of individual herbaceous and woody species, absolute density and frequency of herbaceous species, or absolute frequency of woody species and canopy cover. Total dominance of woody species approaches significant at the 95% level.

The most dominant tree species in the occupied sector of Area I are *Quercus*

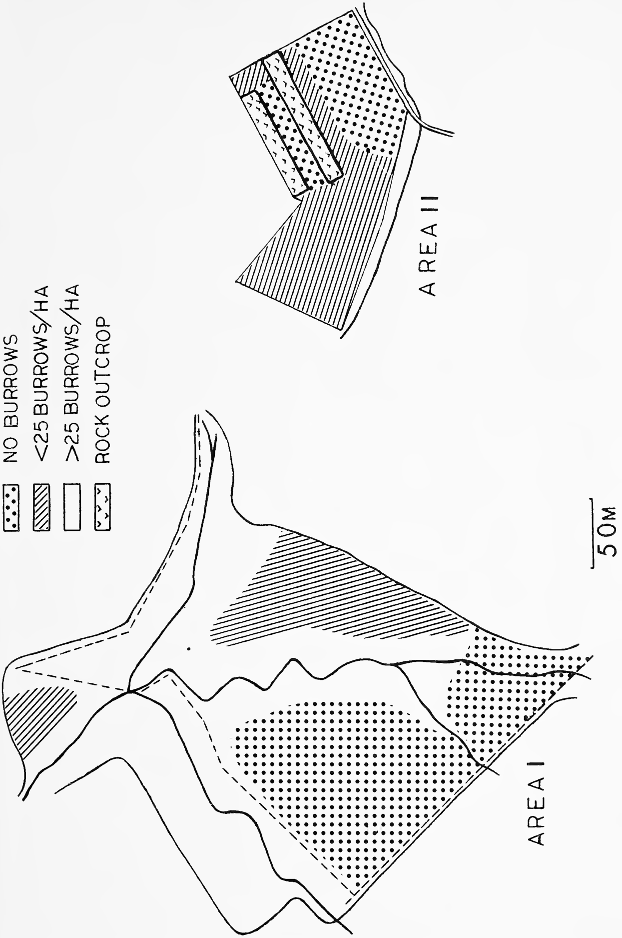

Fig. 1. Chipmunk study areas I and II in southeastern Ohio. Area I is bordered on all sides by cultivated fields or pasture. Area II is a hillside bordered to the west by a road and a stream and continuous with forest on the other sides.

TABLE 1
Vegetative Features of Chipmunk Habitation Areas

	AREA I		AREA II	
	Occupied section (n=21)	Unoccupied section (n=16)	Occupied section (n=4)	Unoccupied section (n=4)
Total density of woody plants/m²	1.83	3.24***	2.12	1.66
Ground cover as percent	22.21	32.73*	30.20	3.38***
Total dominance of woody species	8.95	6.46[1/]	4.66	3.20

(t-test; 1/=1.0>P>0.05, *=0.05, **=0.01, ***=0.001)

alba, *Q. prinus*, *Carya ovata*, *Acer saccharum*, *A. rubrum* and *Liriodendron tulipifera* and at Area II *Carya glabra*, *Betula lenta* and *Sassafras albidum*. In unoccupied sectors of Area I, *Fraxinus americana*, *Ulmus rubra* and *Gleditsia tricanthos* predominate, but at Area II only the shrubs *Viburnum ancerfolium*, *Vaccimium sp.* and *Kalmia latifolia* are common.

Measurements of the characteristics of 25 occupied burrow sites at Areas I and II were taken and analyzed using factor analysis (Rummel 1970). A factor analysis of the 25 variables yields 5 factors accounting for 67% of the total variance (Table 2). These factors are interpreted as follows. Factor I is concerned with variables relating to the position of a burrow on a slope and the vegetative features associated with that site. Canopy cover is less and density of herbs increases on greater slopes resulting in more ground cover, but leaf litter accumulation is less. The age of the animal inhabiting the burrow is correlated with slope. Factor II relates the herbaceous growth to burrow sites and indicates an association of burrows with larger trees. Factor III shows an association of slope to the sex of the occupant of the burrow and a relationship to the position of the burrow on that slope and age of the occupant. Factor IV clarifies the position of the burrow on the slope. Burrow systems on steep slopes are closer to the crest and have more burrow entrances. Factor V further clarifies the position of the burrow on a slope. A burrow located near the crest is most likely to be constructed beneath a solid object such as a stump, root, or large rock. This analysis provides an overview of habitat utilization by chipmunks and a test of specific hypotheses generated from the data. Burrow sites at all locations are in areas of good drainage. Soil composition is a sandy loam with high concentration of sand adjacent to sandstone outcrops.

TABLE 2

Factor Loading Scores of 25 Variables Measured at 25 Chipmunk Burrows in Areas I and II

	FACTORS				
	I[d]	II	III	IV	V
1. Slope	−0.39		−0.51	0.49	
2. Exposure					−0.75
3. Proximity to a solid object					−0.80
4. Distance to herbaceous vegetation			−0.25		
5. Distance to woody vegetation		0.67		0.30	−0.36
6. Sex of occupant			−0.84		
7. Distance to disturbed area	−0.33			−0.65	
8. Number of burrows				0.78	
9. Distance to crest of slope	−0.30		0.25	−0.39	0.61
10. Distance to bottom of slope			0.90		
11. Distance to water			0.95		
12. Age of occupant	−0.46		0.39		
13. Amount of leaf litter	0.66			−0.39	
14. Relative density of herbs		0.81			
15. Relative dominance of herbs		0.66			
16. Relative frequency of herbs		0.60		−0.39	−0.28
17. Importance value of herbs		0.76		−0.33	
18. Tree density	−0.54				
19. Tree basal area	−0.27	0.50			
20. % ground cover	−0.94				
21. % canopy cover	0.68				
22. Total tree density				0.36	
23. Total tree basal area					
24. Absolute density of herbs	−0.91				
25. Total importance value of herbs	−0.56	0.36		−0.36	
Total explained Variation	20%	19%	22%	8%	7%

([d]Zero factor loading is 0.2500 throughout)

Females occupy burrow sites on steeper slopes than do males, but no preference for slope can be found between age classes (Table 3). Twenty-three (26%) burrows were next to or beneath a solid object, 30 burrows (35%) were less than 1 m from a solid object but not beneath one, and 34 burrows (39%) were more than 1 m from a solid object. This distribution is not at variance with random ($X^2_{(2,\ 0.05)} < 2.33$).

TABLE 3

Relation of Chipmunk Burrow Sites to Slope, Sex of Occupant, and Age

	SEX		AGE CLASS	
	Male	Female	Adult	Juvenile
Number	50	37	63	24
Slope ($\overline{Y}$) in degrees	25	34*	29	31

(t-test; * =0.001)

The estimated density of chipmunks, taking into consideration the area of both occupied and unoccupied sections in Area I, was 11.8/ha for Population A and 4.5/ha for Population B. The ecological density was 19.6/ha and 7.5/ha, respectively. The population structure is given in Table 4. The ratio of adults to juveniles is 1:0.11 in Population A and 1:1.25 in Population B.

Discussion

The study areas contained sectors that chipmunks use extensively and other sectors that are not used (see Fig. 1). The presence of burrows characterizes the sectors used by chipmunks. The nonutilized sector of Area I differs from the occupied sector in percent ground cover and the high density of woody plants. At Area II, the unoccupied sector is located between and adjacent to rock-outcrops and is characterized by a sandy soil that supports negligible herbaceous growth and has a low percent ground cover (see Table 1). Stevenson (1962) found chipmunks in areas of heavy understory, and Forsythe and Smith (1973) reported high densities of chipmunks in the dense understory of edge habitats. The habitat of the latter study was characterized by a seasonally-abundant food resource that attracted chipmunks, but it was not determined in either study if the use of the dense understory fluctuated with temporal availability of the food resource and whether or not shifts in burrow systems occurred.

TABLE 4

Age Structure of Populations A and B in 1974

		Population A (n=59)	Population B (n=9)
ADULT	Male	26	3
	Female	27	1
JUVENILE	Male	4	5
	Female	2	0

Extensive lists of foods utilized by chipmunks are given by Howell (1929), Allen (1938), Richmond and Rosland (1949), Yerger (1955), and Siedel (1960). The wide variety of foods utilized by chipmunks indicates that they are able to exist in many types of habitats (Forbes 1966) and that factors other than food resources may be limiting. The occupied sector of Area I is characterized by a slightly higher total basal area (dominance) of woody species than is the unoccupied sector. The mature trees produce a plentiful mast crop and supply an ample food resource in autumn.

Gordon (1969) has described the natural vegetation in Ohio at the time of the arrival of the pioneers and records various accounts of the understory growth. A beech-sugar maple association was typical in southeastern Ohio. Summer herbaceous vegetation was scarce due to the dense shade of the canopy, but vernal and autumnal herbaceous plants were numerous and were those species that depend on animals for seed distribution. Chipmunks are adept seed gatherers, and they store caches of food in their burrows in the fall. The densely-shaded forest floor would also be favorable to growth of fungi, another potential food resource for the chipmunk. The mature forest provides for a food supply beginning in the late fall when the chipmunks become active and abundant and need ample food for weight gain and food caches. Subclimax and disturbed areas are represented by immature trees and shrubs; the latter provide a seasonally-abundant seed crop in autumn. The food resources are not as continuous as in the mature forest.

The optimal situation for chipmunk inhabitation may be hypothesized as a continuously available resource, and the highest densities and stable, reproducing populations of chipmunks would be found in these conditions. Areas of seasonally-abundant food sources attract transient adults and dispersing juveniles during seasonal abundance and are characterized by a fluctuating population density corresponding to availability of food resources (Yahner 1977, 1978a).

Chipmunks belong to the family Sciuridae, a group of primarily diurnal rodents that use visual signals extensively in communication with conspecifics (Svendsen 1973). These signals are necessary to maintain social organization. Dense undergrowth inhibits the flow of visual signals across the communication channel. It is likely that preference would be for areas with less understory growth in order to reduce noise in the channel. The occupied sectors of Area I and Area II have reduced understory growth with mature trees to provide a food supply, whereas the unoccupied sectors are characterized either by heavy herbaceous growth and dense stands of young trees or poor quality soil and poor herbaceous growth. A three-dimensional model relating chipmunk population density to vegetative features and soil conditions is given in Fig. 2. Disturbed areas, such as road banks, fence lines with cleared right-of-ways, and the

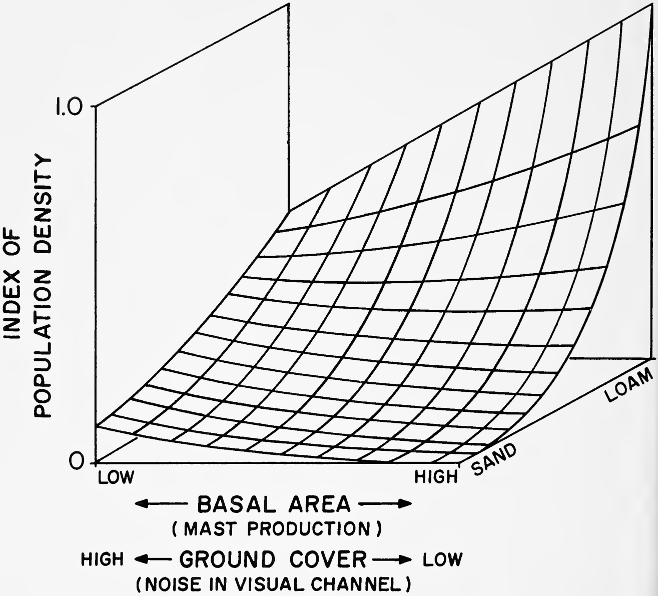

Fig. 2. A three-dimensional graph relating chipmunk population density to soil characteristics and vegetational features based on the data gathered from chipmunk populations in southeastern Ohio.

interface between forest and fields, were not utilized as permanent homesites. Chipmunks, however, would move into these areas in their travel.

Burrow systems of chipmunks have been reported to be located in well-drained soils (Seidel 1960), and we found chipmunk burrows in well-drained soils. The sandy soil along the outcrops at Area II provides excellent drainage, but no burrows were constructed there. High sand content possibly lacks the structural properties to support the tunnels. Chipmunks are known to use rock-outcrops as sites to construct burrows (Damon 1941; Manville 1949). Although no burrows are located in and along the outcrops at Area II, chipmunks did establish burrows at the outcrops of Area III. The soil at Area III is not sandy but a loam similar in texture to the occupied sector of Area I.

Chipmunk burrow systems have been observed beneath or near solid objects such as a fallen log, stump, or rock (Komarck 1932; Burt 1940; Barbour 1951;

Ernst and Ernst 1972; Thomas 1974), as well as in areas away from such structures (Metzgar 1955; Thomas 1974). Based on the 87 used burrows we studied, no relationship between the location of a burrow and the proximity of a solid object is evident. Rocks provide physical support of the burrow entrance of *Marmota flaviventris* in Colorado (Svendsen 1975) and are most important in preventing cave-ins during hibernation. These mountainous soils are formed by erosion and are coarse with little humus or clay content. The sandy soil in Area II is also formed from erosion of the rock-outcrops. *Marmota monax*, a common Ohio burrowing Sciuridae, does not restrict burrow sites to beneath solid objects. Approximately 50% of the burrows are constructed away from such support. Chipmunks may utilize solid objects to burrow beneath in areas in which soils are loose and cannot support burrows as in Area II in which sandy soil is found from erosion of rock-outcrops. This practice is abandoned, however, where soils are more structural in locations distant from the rock-outcrops in Area II.

Females occupy burrow sites on steeper slopes (Table 3) and position the burrow farther from the crest than do males. The preference by females for the steeper slopes within the general topography may be related to conditions of the burrow as a hibernaculum. Females shift burrow sites less during the year than do males (Burt 1940; but see Yahner 1978b) and have a greater tendency to remain in the hibernacula burrow system and raise the young. The data thus may reflect the optimal hibernacula sites, as represented by females, and demonstrate the vagility of the males. Other possible reasons for site selection on steeper slopes by females may be related to food resources and social organization. Hibernacula sites of males are presently being identified, and data relating social organization and food resources are being gathered to test these hypotheses.

The density of chipmunks on Area I is the highest of the study areas, and adults make up the established, burrow-occupying population (Table 4). Only six juveniles from the spring litter became established in the population on Area I, yet several litters were known to have been produced and were seen above ground (Yahner 1977, 1978a). It is presumed that most of the juveniles dispersed from the area and were not able to become established within the stable population already present. Population B is composed of juveniles that occupy a strip 10 to 30 m wide along the outcrop and of adults to the north and northwest of the outcrops. The only adult female on the area is in the latter sector. This female did not produce a litter during 1974. Ninety percent of the females in population A produced litters in 1974; several had two. The overall pattern appears to be a stable, reproducing, adult population in optimal forested areas, with disturbed areas and secondary growth forests serving as secondary habitat, utilized primarily by dispersing subadults and transient adults that have a reduced reproductive effort. The densities of the latter group in any given area respond to what seems to be a locally abundant and erratic food resource.

Acknowledgments

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References

Allen, E. G. The habits and life history of the eastern chipmunk, *Tamias striatus lysteri*. New York State Mus., Bulletin 314, 122 p.; 1938.

Barbour, R. W. The mammals of Big Black Mountain, Harlan County, Kentucky. J. Mamm., **32**(1): 100–110; 1951.

Burt, W. H. Territorial behavior and populations of some small mammals in southern Michigan. Misc. Publ. Zool., Univ. Mich., **45**: 1–56; 1940.

Cox, G. W. Laboratory manual of general ecology. Wm. C. Brown Co., Dubuque, Iowa, 45 p.; 1972.

Damon, D. Notes on the gray eastern chipmunk. J. Mamm., **22**: 326–327; 1941.

Ernst, C. A.; Ernst, E. M. The eastern chipmunk, *Tamias striatus*, in southwestern Minnesota, U.S.A. Can. Field Natur., **86**: 377; 1972.

Forbes, R. B. Studies of the biology of Minnesotan chipmunks. Amer. Midl. Natur., **76**(2): 290–308; 1966.

Forsyth, D. J.; Smith, D. A. Temporal variability in home ranges of eastern chipmunks (*Tamias striatus*) in a southwestern Ontario woodlot. Amer. Midl. Natur., **90**(1): 107–117; 1973.

Gordon, R. B. The natural vegetation of Ohio in pioneer days. Bull. Ohio. Biol. Survey, **111**(2), 109 p.; 1969.

Hall, E. R.; Kelson, K. R. The mammals of North America. Ronald Press, New York, 2 Vols.; 1959.

Howell, A. H. Revision of the American chipmunks (Genera *Tamias* and *Eutamias*). N. A. Fauna, No. 52, 157 p.; 1929.

James, F. C.; Shugart, Jr., H. H. A quantitative method of habitat description. Audubon Field Notes, **24**(6): 227–236; 1970.

Komarke, E. V. Notes on mammals of Menominee Indian Reservation, Wisconsin. J. Mamm., **13**: 203–209; 1932.

Manville, R. H. A study of small mammal populations in northern Michigan. Misc. Publ. Mus. Zool., Univ. Mich., **73**: 1–83; 1949.

Metzgar, B. Notes on mammals of Perry County, Ohio. J. Mamm., **36**: 101–105; 1955.

Richmond, N. D.; Rosland, H. R. Mammal survey of northwestern Pennsylvania. Final Report, P–R Project 20–R, Pa. Game Comm., 67 p.; 1949.

Rummel, R. J. Applied factor analysis. Northwestern Univ. Press, Evanston, Ill., 617 p.; 1970.

Seal, H. L. Multivariate statistical analysis for biologists. Metheun, London, 209 p.; 1968.

Seidel, D. R. Some aspects of the biology of the eastern chipmunk, *Tamias striatus lysteri* (Richardson). Cornell Univ.; 1960. 147 p. Dissertation.

Sokal, R. R.; Rohlf, F. J. Biometry. Freeman, San Francisco, 776 p.; 1969.

Stevenson, H. M. Occurrence and habits of the eastern chipmunk in Florida. J. Mamm., **43**: 110–111; 1962.

Svendsen, G. E. Mirror image stimulation applied to field behavior studies. Ecology, **54**(3): 623–627; 1973.

———. Structure and location of yellow-bellied marmot burrows. Southw. Natur., **20**(4): 487–494; 1975.

Thomas, K. R. Burrow systems of the eastern chipmunk (*Tamias striatus pipilans* Lowery) in Louisiana. J. Mamm., **55**: 454–459; 1974.

Yahner, R. H. Behavior and social system in the eastern chipmunk, *Tamias striatus*. Ohio University; 1977. 79 p. Dissertation.

———. The adaptive nature of the social system and behavior in the eastern chipmunk, *Tamias striatus*. Behav. Ecol. Sociobiol., **3**: 397–427; 1978a.

———. Burrow system and home range use by eastern chipmunks, *Tamias striatus*: ecological and behavioral considerations. J. Mamm., **59**: 324–329; 1978b.

Yerger, R. W. Home ranges, territoriality and populations of the chipmunk in central New York. J. Mamm., **34**: 488–498; 1953.

———. Life history notes on the eastern chipmunk. *Tamias striatus lysteri* (Richardson), in central New York. Amer. Midl. Natur., **53**: 312–323; 1955.

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THE KIRTLAND-STORER CORRESPONDENCE ON OHIO FISHES (1838-45) AND A KIRTLAND-BAIRD COLLECTION OF OHIO FISHES (1853)

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Abstract

Excerpts from 22 letters that Dr. Jared Potter Kirtland sent to Dr. David Humphreys Storer (1838-45) have been selected to illustrate the problems Kirtland faced in developing studies on the fishes of Ohio, and his growth from a beginner to the leading authority on the fish fauna of Ohio.

Also, a list of 45 species of fishes collected by Dr. Kirtland and Spencer Fullerton Baird in August of 1853 from Yellow Creek and the Mahoning River is given with a list of 16 species reported to them from the area, but not collected by them. Current names as recognized by Trautman (1957) are added.

Introduction

Between 1838 and 1845, Dr. Jared Potter Kirtland, the first important naturalist in northeastern Ohio, wrote 22 letters concerning his study of Ohio fishes to Dr. D. Humphreys Storer of the Boston Society of Natural History. These have been edited to show Dr. Kirtland's problems in

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Fig. 1. Dr. Jared Potter Kirtland (1793-1877), first authority on the fishes of northern Ohio. Photo from a painting in The Cleveland Museum of Natural History.

studying the fish fauna in an unexplored area and with very limited available literature to guide him. They also show Kirtland's growth from a beginner in the field to the leading authority on Ohio fishes, through the aid of Dr. Storer.

Dr. Kirtland (1793-1877), born and reared in Connecticut, joined his father, the founder of Poland, Ohio, in 1810 to teach school and study the natural history of the area. After his medical education at Yale University and a brief period of medical practice in Connecticut, he returned to Poland (a suburb of Youngstown) in 1823 to practice medicine and to continue his studies of natural history. In 1836-37 he was in charge of zoology for the first Geological Survey of Ohio. In his *Report on the Zoology of Ohio* (1838) he described many new fishes. Also in 1837, he bought a farm at East Rockport (now Lakewood) which he developed into an experimental farm for horticulture and bee-keeping, as well as headquarters for his extensive field studies and medical practice. He also taught part-time at several medical schools (Cleveland, Willoughby, Cincinnati). During his scientific career he published 79 reports on Ohio fishes, which are listed in Trautman's classic monograph on *The Fishes of Ohio* (Trautman 1957: 628-630). Included is a series of papers on the fishes of the Ohio River, Lake Erie, and their tributaries published in the *Proceedings of the Boston Society of Natural History* and the *Boston Journal of Natural History*. Kirtland also republished these articles in his newspaper, "The Family Visitor," issued simultaneously in Cleveland and Hudson. This weekly paper maintained a regular column for natural history. Kirtland was a founder of and leader in the Cleveland Academy of Natural Sciences, which later became the Kirtland Society of Natural History, the prototype of the Cleveland Museum of Natural History.

Dr. Storer (1804-91), a native of Maine, was graduated from the Harvard Medical School in 1825 and practiced medicine in Boston until 1888. He was one of the founders of the Tremont Street Medical School which later merged with the medical department at Harvard. He served as both professor and dean at the Harvard Medical School. In 1837 he was placed in charge of zoology and herpetology for the Massachusetts Geological Survey, and he was a founder of the Boston Society of Natural History. Among his major publications on fishes are the *Report on the Ichthyology and Herpetology of Massachusetts* (1839), *Synopsis of the Fishes of North America* (1846a), and *History of the Fishes of Massachusetts* (1853-57). Also, he summarized Kirtland's work on the fishes of Ohio for the Boston Society of Natural History (1846b).

D. Humphreys Storer

Fig. 2. Dr. David Humphreys Storer (1804-1891), who aided Kirtland in his studies on Ohio fishes. Photo from an engraving, courtesy of Museum of Science, Boston.

The Kirtland-Storer Correspondence on Ohio Fishes (1838-45)

On 13 July 1838, Dr. Kirtland, writing from Poland in Trumbull County, sent his first letter to Dr. Storer by way of introduction and a request for assistance.

> "In organizing the Geological Board for the Survey of this State, the Botanical and Zoological departments are committed to my charge. I expected to visit your city during the present season with a portion of my collection of Fishes, Reptiles, and Insects for the purpose of soliciting aid in arranging them from yourself and Dr. [T. W.] Harris, and your brother [Hon. B. Storer] at Cincinnati had the goodness to favor me with the enclosed letter of introduction, but our Legislature having failed to make an appropriation for carrying on the Survey, I am compelled to relinquish my contemplated journey. The Survey will probably be discontinued, but I am determined to pursue the subject of ichthyology till I become familiar with all that our state affords in that branch of Natural Science. I have devoted most of the present season to the collecting of specimens from Lake Erie or from the tributaries of the Ohio and would now take the liberty of communicating with you for the purpose of reducing the result of my labors to some order. In all busineses there must be a beginning; it will be unnecessary for me to add that the following is my first effort at attempting to reduce our fishes to a scientific arrangement.
>
> "Isolated as I am in the interior of a newly settled country without the aid of suitable books, the knowledge of what has been done by others or even the aid of any one who takes the least interest in the subject, every step that I take leads into new doubts and perplexities. No other apology I trust will be required for my abrupt intrusion on your attention."

The letter was accompanied by a list of 52 species of fishes, some with tentative identification, and with notes and questions concerning his doubts about identity. Undoubtedly many errors needed to be corrected. His letter continued:

> "Will you favor me by correcting any errors in the above list by supplying if possible names where they are omitted and by adding any species of Ohio fish that I have not included. . . .
>
> "Enclosed is a ten dollar bill. I wish to become a subscriber to your Translation of Keiner [work on shells]."

Five weeks later, having received no word from Dr. Storer, and realizing the mails were not always dependable, he wrote again.

> "As our mails are an unsafe source for transmitting money, even in small sums, and I have neither received any numbers of your Translation nor an answer to my long communication on the subject of Our Western Fishes, I conclude the letter must have failed to reach its proper place of destination. . . . I shall leave home to resume my labors in the Ohio Medical College at Cincinnati on the 20th of October and it is highly important to me, to obtain both your Translation of Keiner and all the information in regard to our Fishes that I possibly can, previous to my departure.
>
> "Since my former letter I have incidentally learned that you have published a *Report of the Fishes of Massachusetts*. Is it a form in which you could furnish me with a copy through the Post Office? I have lately been comparing Rafinesque's publication *On the Fishes of the Ohio River* with the fishes themselves. I find that he has described most of the species that actually exist as well as a great number that are only imaginary. He has rather thrown darkness than light over the subject."

Rafinesque has been severely criticized by many naturalists through the years, usually with justification, but David Starr Jordan came to his defense in regard to at least one publication on fishes by Rafinesque, writing, "descriptions are much better than he has been given credit for" (Dexter 1956).

After receiving two letters and the second installment of Storer's Translation of Keiner's book on shells, Kirtland wrote back to Storer on 28 September 1838.

> "A few days before the arrival of your last letter I unexpectedly received Rafinesque's publication on the *Fishes of the Ohio River* contained in a series of numbers in the *Western Review* which I suppose contains the substance of his publication to which you alluded. By means of his descriptions and your explanations I have been able to arrange our fishes in a far more satisfactory manner than I anticipated. To do Rafinesque justice I must say that he knew far more about the fish than he did the shells of the Western Waters. His descriptions are not very plain and clear, but with close examination will be found to be more accurate than first view of them would lead one to suppose. He certainly must have expended much time and labor in his investigations of our fish. In a number of instances he has made species out of varieties. My catalogue now contains 64 species, one or two of them are doubtful.
>
> "It is probable that I shall continue to examine all of our fish till I get familiar with them. Should it be thought advisable to undertake a new arrangement of them, I shall have no objection to commence the [work]

> next season as I shall resign my station in the Geological Board not choosing to be at the mercy of every political fluctuation.
>
> "Would the Society [Boston Society of Natural History] be willing to publish full and accurate *Descriptions of the Fishes of Ohio* with plates if I should furnish them in series from time to time?"

Over the ensuing eight years Kirtland published a series of papers on his studies of Ohio fishes in the publications of the Boston Society of Natural History (Kirtland 1839-46). Not all of the illustrations submitted, however, were published with the text. A collection of 57 Kirtland's original drawings, including some that were not published, were brought to light by Moulton (1957). Also, Kirtland complained to Storer that "Lake Erie" had been left out of the title in the early issues. Of the eight installments, "Lake Erie" was included in the title only three times.

Kirtland continued his periodic reports to Storer on 1 October 1838.

> "I have been busily engaged for several days in describing and figuring *five* new species of our Western Fishes and had completed them last evening except making corrections. I had also written you a long letter which was in the same unfinished state. This morning I very accidentally met with a gentleman, a passenger in the stage, on his way to your city who had the goodness to take charge of my letter, drawings, and manuscript and says that he will deliver them to you in the course of three weeks. I had no alternative except to either [take] his offer and send them uncorrected or to lose a chance that might not again occur in many months. I therefore concluded it was most advisable to send them and tax you with the trouble of making any verbal corrections or supplying any omissions that are evident in the descriptions before they are published. In the main they are correct. The drawings are the result of my first serious attempt with the pencil. Connoisseurs will, without doubt, discover many awkward points in them, but I believe they will serve to illustrate the species sufficiently for Naturalists. They are at least as well executed as Rafinesque in the *Journal of the Academy of Natural Sciences of Philadelphia.*
>
> "I shall leave home on the 15 inst. [of month] to resume my duties in the Medical College at Cincinnati and of course shall not have much leisure to continue the investigation of our Fishes during the winter. Still, every market morning I intend to visit the fish stalls before sunrise and shall without doubt occasionally find something interesting.
>
> "In arranging our Percoides I hesitated whether to place together those species described by Lesueur as *Cickla aenea, fasciata, minima* and *ohioensis* and to add to the same genus my new species or to place the

> *aenea* of *Storeria* under Curvier's genus *Centrachus*. On repeated examination I can find no good reason for separating them except the two latter have slight dentations or serrations on the angle of the preoperculum and I have at length concluded to place them together under the genus *Cickla* of Schneider. They differ from it in having scaly opercula, his character is 'operculi smooth.'
>
> "If you think I am incorrect in this, will you have the goodness to change the generic name of *Cickla storeria* to *Centrachus* both in my description and on the plate. [all species of Cickla are now regarded as synonyms. See Trautman 1957: 35.]
>
> "With my limited opportunities I find it very difficult to decide with certainty upon the minute characters which distinguish many of Cuvier's genera of fishes especially as I have only McMustin's abridged translation to reports. . . . If it would be of any value to the collections of your Society [Boston Society of Natural History] I would with pleasure add to it specimens of most of our Ohio Fishes."

After receiving two letters from Storer, Kirtland wrote from Cincinnati, where he was teaching in the Ohio Medical College, on 14 January 1839.

> "The freedom with which you pointed out the discrepancy between the figure and description of the Gray Bass was received with the utmost spirit of kindness and thankfulness on my part and I shall always feel grateful to you for any corrections of errors of that character. The subject of Ichthyology is new to me and when I turned my attention to it last year it seemed to be surrounded with so many obstacles that I despaired of ever covering them. Your aid has enabled me to progress so far with our Western Fishes that I have been enabled to form a catalogue of 73 species which I have reported to our Legislature in my Annual Geological Report. [see Kirtland 1838]
>
> "I shall soon be able to forward you our Geological Report and when I do it, will take the liberty of asking a great variety of questions in regard to many of the species and hope you will favor me with your views in regard to them. I hope and trust you will use the utmost frankness and freedom in pointing out to me every error. I know you would do it if we were personally acquainted and I assure you that under existing circumstances you need not feel the least restraint.
>
> "My catalogue is not reported with the expectation that it is now totally correct and is considered *only as the first step* towards the development of certain branches of the natural history of our state. It was drawn forth prematurely by the course pursued by our Legislature

> and whether I shall pursue the subject any further under their control is doubtful and depends upon the course they take with the Survey and with our Medical College during their present session. If they make a favorable move I shall continue in my present station; if they do not I probably shall resign both my professorship and my situation in the Geological Board. In the latter case I shall continue my investigations and should be glad to make your Journal the medium for laying before the public the results of my labors. A few weeks will determine my course. [The Geological Survey was not continued at that time.]
>
> "The Dog-fish of Lake Erie proves to be the *Amia calva* of Linnaeus . . . . My brother informs me that he met with it on the upper waters of the Mississippi above Prairie du Chein. . . . I have lately found a few specimens of a neat-looking sucker (Catostomus) in this market that is not described by Lesueur or Rafinesque and a lamprey (Petromyson) that is new to me. . . .
>
> "If you think the other portions of my former communication sufficiently correct to be worthy of publication you can lay them before the public, but as it was among my first attempts at drawing I do not feel very anxious to see them in that form. Having attended to some instruction in drawing during the winter I shall be able in future to make them more correct and in better style."

After his return to the Cleveland area, Kirtland sent a letter, a manuscript, and descriptions and drawings of 15 Ohio fishes for Storer's appraisal on 20 September 1839.

> "You will receive accompanying this letter, drawings and descriptions of 15 species of fishes inhabiting our Western Waters, together with a communication to the Boston Society of Natural History. I have committed them to your charge with the expectation that after you have examined them you will make such disposition of them as you think they merit. If you think they are executed sufficiently well and the object is of importance enough, you will please to lay them before the Society, after correcting the errors. If on the other hand my attempt falls so far short of what the subject requires you will without hesitation retain them in your own hands and never let them go before the Society. I rely solely on your candor and judgment and shall be fully satisfied whatever decision you make. [Kirtland's letter was read at the meeting of the Boston Society of Natural History on 15 October 1839, a report of which was published in the *Proceedings* without the illustrations (Kirtland 1839). Later, the manuscript with some of the illustrations was published as the first issue in his series (Kirtland 1840).]

> "I have been lately occupied during the summer in changing my location from Poland [suburb of Youngstown] to this city [suburb of Cleveland] which I hope will in future relieve me from many of my interruptions and enable me to pursue my studies with greater facility."

Pleased with the appearance of his work, Kirtland wrote at once on 18 November 1839 from Cincinnati.

> "The engraver executed those first drawings in a manner far exceeding my expectations for I was apprehensive that they would appear like Rafinesque in the *Journal of Natural Sciences* (Philadelphia) [*Journal of the Academy of Natural Sciences of Philadelphia*].
>
> "Since my last letter I have succeeded in obtaining a specimen of the *Perca chrysopa* [now *Roccus chrysops* (Rafinesque), White Bass] from the Ohio [River]. It is specifically identical with that of Lake Erie but of a darker color. It must however be placed under the genus *Labrax* rather than *Perca* as it has 2 spines on the operculum. It is toothed on the tongue and palate. One of the spines is rather obtuse and not very evident.
>
> "The other fish I shall describe under the name *Chatoessus ellipticus* [now *Dorosoma cepedianum* (Le Sueur), Eastern Gizzardshad]. Rafinesque, I believe, had this fish in view when he wrote his description, but he must have been extremely careless."

Following receipt of a copy of Storer's *Report on the Ichthyology and Herpetology of Massachusetts* (1839), Kirtland wrote to the author complimenting him on his success and disparaging himself on his own efforts. Kirtland was too modest and self-effacing even though his work on fishes had just begun. He wrote 16 December 1839:

> "It affords me much satisfaction to see the ichthyology of your section of the country so fully and amply elucidated, but the perusal of your publication has served to strengthen me in the conviction that I have prematurely engaged in an attempt to illustrate that department of natural science so far as the state of Ohio is concerned. In every movement I make in investigating the subject I find myself surrounded with perplexities and obscurity without the means of extricating myself. I have neither a friend who knows one fish from another nor a book on the subject to which I can apply with the exception of Rafinesque's and Lesueure's publications. A still more insurmountable obstacle thwarts my advancement in the undertaking. My efforts at drawing are sufficiently puerile, but my attempts at describing are so stiff, awkward, and in such bad style that my productions will probably do your journal more injury than good."

Upon completing his term of teaching at the Ohio College of Medicine in Cincinnati, Kirtland sent the following letter 28 February 1840. Notice his interest in parasitic worms and land snails as well as fishes.

> "I have this day packed up drawings and descriptions of the following [27] species of fishes. These I have figured and described since I came to this city [Cincinnati] on the 20th of Oct. . . .
>
> "On opening 3 specimens of the *Polyodon folius* [now *P. spathula* (Walbaum), Paddlefish] I found a number of tapeworms in the stomach of two of them. These parasites I have preserved and they will be forwarded by Mr. [J. G.] Anthony to the Boston Society of Natural History. I would observe that I have also discovered them in the stomach of dogs and suckers as well [as] of the Human family. . . .
>
> "If your conchologists were as well acquainted with the peculiar habits of the *Helix striatella* of Anthony [now *Discus cronkhitei* (Anthony)] as I am they would not consider it the young of the *H. perspectiva* [now *Discus patulus* (Deshayes)]. I recognized it as a distinct species in 1834. I sent specimens to Wm. Hyden of Philadelphia who compared it with the *perspectiva*.
>
> "My attention will be paid during the summer to the smaller species of fish among which I expect to find some that are new and no one except Rafinesque has ever known any two of them apart. At least such is the fact among our best naturalists."

Continuing his disagreement with some of Rafinesque's descriptions of new species, Kirtland wrote from Cleveland 11 May 1840:

> "The *Noturus flavus* [Stonecat Madtom] and *Pimelodus nebulosis* [now "presumably *Pilodictis olivaris*," Flathead Catfish, according to Trautman 1957: 42] of Rafinesque I believe complete all the species of this family that exist in our western waters, with perhaps one exception. I once saw a small species that I have not met with of late years. The other species of Rafinesque are I believe mere varieties.
>
> "I shall feel myself under great obligation to you to make every alteration and every addition to my descriptions that you may think proper. Independent of my want of sufficient knowledge of the subject I am harried and perplexed with the multiplicity of my pursuits and since my removal to this place am taxed with the additional burden of formality and the routine of fashion incidental to a city-life—a burden not very pleasant to one who is attempting to be a practical naturalist. . . .
>
> "I perhaps was misled in regard to the anatomical structure of the *Lepidosteus* by a dissection made by one of my students and without

sufficient examination mistook the natatory bladder, which is cellular, for a lung. 'The smaller species in the tributaries of the lake [Lake Erie] have not yet been examined I believe by any one and they may be essentially different from those in the lake itself."

In the same vein, he wrote 3 August from Cleveland:

> "During a late excursion into the County of Columbiana I found the *Pimephales promilas* abundant in the upper branches of the Little Beaver [River] and I have no doubt from further examination that the *male* is Rafinesque's *Hypentelium macropterum*. It differs in form from the female—is longer and has the habit of gathering around the beds of the female in great numbers early in June. The inventive genius of that author [Rafinesque] could easily form from it a new species."

And again on 28 December 1840, from Cincinnati:

> "From repeated examination I am led to the conclusion that the *Accipenser maculosus*, *nudus*, *ohioensis*, *macrostomus*, and *serotinus* are only varities of one species arising from age and sex."

Kirtland was keen in detecting similarities as well as differences among organisms he studied. His conclusion concerning Accipenser [sturgeon] was correct. Trautman (1957) recognized only one species in Ohio (see Moulton 1957 for Kirtland's illustrations of Accipenser). On 25 January 1841 Kirtland wrote further on that problem.

> "During the last season I have met with all these species [*Accipenser maculosus*, *rubicundus*, *serotimus*, *ohioensis*, and *macrostomus* described by Lesueur and Rafinesque], both in the lake and the Ohio River and with others again which could with equal propriety be described as new species. By close observation it will, however, be found that they all run one into another and the distinctions are owing to *locality*, *age*, and *sex*. . . ."
>
> "On further examination I suspect the large minnow a drawing of which I sent, under the name of *Rutilus playgrus* of Rafinesque is a new species [later named *Rutilus storeria* Kirtland.] It inhabits the deep waters of Lake Erie exclusively. I have since taken what I deem to be the true *R. playgrus* [now *Notropis cornutus chrysocephalus* (Rafinesque), Central Common Shiner] and will soon send a drawing of it. . . ."

Kirtland's poor health occasionally interrupted his scientific studies, but he nevertheless accomplished a prodigious amount of scientific work in addition to his medical practice and teaching. Notice in the letter to follow his belief in "marsh miasmata" as a cause of his sickness before the role of mosquitoes in transmitting disease was discovered. Kirtland wrote 20 February and again 17 June 1841:

> "My health is too bad to allow me to write or study much at this time, as I am suffering severely from a persistent Hemicrania—the effect of my last year's exposures to marsh miasmata in the Cuyahoga swamps."
>
> "Either long exposure to miasma about the swamps and rivers or to the fumes of arsenic in putting up birds last autumn induced a daily attack of neuralgic pains in different parts of the fifth branch of nerves resembling Tic-Doloreaux. . . . Under these circumstances I have thrown aside my books and studies and since my return from Cincinnati have rode, every pleasant day, to my farm 5 miles from Cleveland [Rockport, now Lakewood]. That exercise with the use of strong beer and Graham bread has improved my health so much that I am now beginning to turn my attention again to my favorite pursuits."

Six months later, still having health problems, he announced his plans for the future in a letter to Storer on Christmas Day, 1841:

> "At the close of the present term (1st of March) I shall resign my station in this Institution [Ohio Medical College] and return to my farm five miles west of Cleveland [in Rockport]. Though my health is apparently restored this winter, I still find my constitution giving way under my duties here and my infirmities warn me to change my life and habits. I may perhaps be induced to accept a professorship in the Willoughby Medical School 20 miles east of Cleveland where the duties would be much easier and I should not be separated for any considerable time from my family and business.
>
> "I hope to be able to devote my time mostly to natural science and horticulture. My farm is one of the surest and best for fruit in the U.S. The immense volume of water in the lake moderates the temperature of the air in its vicinity during the winter and the silicous and calcaruous combination of soil reflects heat to a high degree during summer and autumn so that we neither suffer from frosts in spring or fall nor from the want of high temperature to mature the fruits of summer and autumn."

By 1 June 1842 he was settled on his farm at Rockport, with a new house under construction. As he wrote to Storer from Cleveland:

> "Before I left Cincinnati I resigned my station in the Medical College of Ohio and accepted an appointment in the Willoughby Institution 20 miles east of Cleveland. I have also returned to my farm 5 miles west of this place. I am now busily engaged in superintending the building of my house etc. preparatory to a permanent residence in the country."

His last letter to Storer, written 29 May 1845, concerned his final installment on the fishes of Lake Erie, the Ohio River, and their tributaries, and his hopes for the future.

> "After a long delay from causes beyond my control, I have at length completed the drawings and descriptions of our Western Fishes which I shall forward to you in a few days. . . .
>
> "After three years hard struggling we have at length got our Cleveland Medical College in a safe condition. The building will be so far completed as to be used for lecturing the ensuing winter. One story is to devote to cabinets of natural science [Museum of the Cleveland Academy of Natural Sciences]. After this I hope my time will be occupied in arranging and studying those cabinets and not with medical politics as it has been for three years."

The balance of his life was given largely to natural history and horticulture, especially developing new varieties of fruits, particularly cherries. He did not, however, publish much more beyond brief notices on the fishes of Ohio.

A Kirtland-Baird Collection of Ohio Fishes (1853)

Between 8-12 August 1853 Spencer Fullerton Baird joined Dr. Kirtland at Poland, Ohio, to make a collection of fishes from Yellow Creek and an adjacent section of the Mahoning River. The Mahoning is a tributary of the Big Beaver which empties into the Ohio River at Beaver, Pennsylvania. There is no indication where the specimens were sent. Some or all may have been sent to the Smithsonian Institution where Baird was the Assistant Secretary and was on the staff of the museum.

Spencer Fullerton Baird (1823-87) was a native of Reading, Pennsylvania. Five years after graduating from Dickinson College in 1840, he returned as professor of natural history. In 1850 he was appointed Assistant Secretary of the Smithsonian Institution. He donated his personal collection of zoological specimens, including a great many fishes, which became the nucleus for the collection of the U.S. National Museum (now National Museum of Natural History), and he prepared the Smithsonian "Instructions to Collectors," which was widely circulated among American naturalists. Since 1847 Baird had served as U.S. Commissioner of Fish and Fisheries.

Some or all of the collection of 1853 may have been sent to the Museum of Comparative Zoology at Harvard University or to the Boston Society of Natural History. Kirtland was known to send specimens to those

Fig. 3. Spencer Fullerton Baird (1823-1887), U.S. Commissioner of Fish and Fisheries, who, along with Storer, aided Kirtland in his studies on Ohio fishes. Smithsonian Institution Photo No. 46,853.

institutions. Nothing was published on the collection as a unit, but records may have been used in connection with other studies. In any case, Baird's notes on the collection came to the attention of Frederic W. Putnam.

Frederic Ward Putnam (1839-1915) was a student under Louis Agassiz and was in charge of the fish collection at the Museum of Comparative Zoology. Until he completed his studies at Harvard, he served as part-time curator of ichthyology for the Boston Society of Natural History. He became curator of the museum of the Essex Institute in 1864, and the first director and curator of vertebrates for the Peabody Academy of Science (now the Peabody Museum of Salem) when it was founded by George Peabody in 1866. All of these museums were in touch with Baird at the National Museum, and Putnam made periodic trips to Washington to study the fish collection. At one place or another, Putnam acquired Baird's notes on the Kirtland-Baird collection of 1853 and made a copy (in his own handwriting) which is now in the archives of the Peabody Museum of Salem. To this copy Putnam added detailed notes on his study of the Etheostomids (darters), his own specialty of ichthyology (Dexter 1966, 1970). The original identification of the fish collection, however, was probably made by Baird.

The current scientific names and the preferred English names are taken from Trautman, *The Fishes of Ohio* (1957). Of the 41 species collected, only two remain with the same name unchanged, and three others had only a minor change in the name. Eleven species are not listed by Trautman, so probably were incorrectly identified.

List of 41 species collected by Kirtland-Baird (1853)

Those marked with an asterisk were originally described by Kirtland.

Catastomus nigricans (*Hypertelium nigricans*) Hog Sucker
C. communis? (*C. commersoni commersoni*) Common White Sucker
C. duguesnii? (*Moxostoma* spp.) Red Horse
Exoglorum dubium (*Campostoma anomalum anomalum*) Ohio Stoneroller Minnow
Rhinichthys astronasus-ordis (*R. atratulus meleagris*) Western Blacknose Dace
R. erythropterus? (probably sp. above)
Leuciscus playgrus (*Notropis cornutus*) Common Shiner
L. americanus (*Notemigonus crysoleucas*) Goldenshiner
L. atromaculatus (*Semotilus atromaculatus atromaculatus*) Northern Creek Chub

**L. biguttatus* (*Hybopsis biguttata*) Hornyhead Chub
L. cf. blennoides of Carlisle (not listed by Trautman)
L. longirostus Kirt. (*Clinostomus elongatus*) Redside Dace
L. erythrogaster (*Chrosomus erythrogaster*) Southern Redbelly Dace
**L. elongastus* (*Clinostomus elongatus*) Redside Dace
L. kentuckiensis (*Hybopsis micropogon*, or *H. biguttata*) River Chub
Albrunus rubellus? (not listed by Trautman)
Albrunus sp. (possibly *Notropis atherinoides atherinoides*) Common Emerald Shiner
Pimephales promelas? (*P. promelas promelas*) Northern Fathead Minnow
P. elongatus (not listed by Trautman)
**Melanura limi* Mud fish. (*Umbra limi*) Central Mudminnow
Athermoid new gen. (not listed by Trautman)
Pomotis vulgaris (probably *Lepomis gibbosus*, or *L. megalotis*) Pumpkinseed Sunfish
P. nitidus (*Lepomis megalotis*) Longear Sunfish
Pomotis n. sp. Sunfish
Esox fasciatus? (not listed by Trautman)
Centrarchus hexacanthus (*Pomoxis annularis*) White Crappie
C. aeneus (*Ambloplites rupestris rupestris*) Northern Rockbass
Grystes fasciatus? (not listed by Trautman)
Pimelodus limosus (*Pilodictus olivaris*) Flathead Catfish
P. flavus? (not listed by Trautman)
Naturus flavus, Stonecat Madtom
**Gasterosteus inconstans* (*Eucalia inconstans*) Brook Stickleback
Cottus bairdii, Redfin Sculpin
**Etheostoma variata* (*E. variatum*) Variegated Darter
**E. maculata* (*E. maculatum*) Spotted Darter
E. marginata (not listed by Trautman)
E. tesselata (not listed by Trautman)
E. pellucida (*Ammocrypta pellucida*) Eastern Sand Darter
E. notata (not listed by Trautman)
E. (elyria) (not listed by Trautman)
E. caprodes (*Percina caprodes caprodes*) Ohio Logperch Darter

Four other species were listed as "caught on a preceding visit."

**Leuciscus dissimilis* (*Hybopsis dissimilis dissimilis*) Ohio Spotted Chub
Etheostoma blennioidi (*E. blennioides*) Greenside Darter
Etheostoma sp., Darter
Rhinichthys sp., Dace

The following 16 species were recorded as having been reported to Kirtland and Baird from the same area, but were not collected by them.

Anguilla sp., Eel

Ammocoetes, Larval Lamprey
Petromyzon sp., Lamprey
Lucioperca americana (*Stizostedion* spp.) Walleye
L. canadensis (*Stizostedion canadense*) Sauger
Lepidosteus sp., Gar
Catostomus anisurus (*Moxostoma anisurum*) Silver Redhorse
Catostomus sp., Sucker
Leuciscus sp. Shiner
Labrax multilineatus (*Roccus chrysops*) White Bass
Corvina oscula (*Aplodinotus grunniens*) Freshwater Drum
Hyodon tergisus (*Hiodon tergisus*) Mooneye
Chatoessus sp. (probably *Dorosoma cepedianum*) Eastern Gizzardshad
Acipenser sp., Sturgeon
Polyodon folium (*P. spathula*) Paddlefish
Pimelodus funatus (not listed by Trautman) Catfish

Acknowledgments

I am indebted to Edward Pearce, Librarian at the Museum of Science, Boston, for the privilege of studying and quoting from the papers of Dr. D. Humphreys Storer in the archives of that institution; and to the late Dr. Ernest S. Dodge, Director of the Peabody Museum of Salem for permission to quote from the F. W. Putnam papers, including the S. F. Baird notes on Ohio fishes, in the archives of that museum.

References

Dexter, R. W. Jordan on Rafinesque. Systematic Zoology **5**: 46-47; 1956.

Dexter, R. W. Historical note on Kirtland's study of Ohio darters. The Explorer **8**: 25-29; 1966.

Dexter, R. W. Historical aspects of F. W. Putnams's systematic studies on fishes. Jour. Hist. Biol. **3**: 131-135; 1970.

Kirtland, J. P. Report on the zoology of Ohio. Annual Report Geological Survey of the State of Ohio, **2**: 157-197; 1838.

Kirtland, J. P. Fishes of Ohio. Proceed. Boston Soc. Nat. Hist., in: Amer. Jour. Sci. and Arts **38**: 392; 1839.

Kirtland, J. P. Descriptions of the fishes of the Ohio River and its tributaries. Boston Jour. Nat. Hist., **3**: 338-352; **3**: 469-482; **4**: 16-26; **4**: 303-308; **5**: 21-32; 1840-45.

Kirtland, J. P. Descriptions of the fishes of Lake Erie, the Ohio River, and their tributaries. Boston Jour. Nat. Hist. **4**: 231-240; **5**: 265-276; **5**: 330-344; 1842-46.

Moulton, J. M. A collection of drawings of fishes ascribed to J. P. Kirtland (1793-1877) in the library of Bowdoin College. Breviora No. 80, 4 pp; 1957.

Storer, D. H. Report on the ichthyology and herpetology of Massachusetts. Boston: Dutton and Wentworth, State Printers; 1839.

Storer, D. H. A synopsis of the fishes of North America. Mem. Amer. Acad. Arts and Sci. Vol. 2; 1846a.

Storer, D. H. A synopsis of the fishes of the state of Ohio, prepared from the papers of Prof. J. P. Kirtland, published in the journal of this society. Proceed. Boston Soc. Nat. Hist. **2**: 103-105; 1846b.

Storer, D. H. History of the fishes of Massachusetts. n.p.; 1853-57.

Trautman, M. B. The fishes of Ohio. The Ohio State University Press; 1957.

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NOTES ON BOVIDAE (MAMMALIA) FROM THE HADAR FORMATION, AND FROM AMADO AND GERARU, ETHIOPIA

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Abstract

Bovidae are well represented in the Pliocene Hadar Formation, members SH and DD. They comprise two large tragelaphines, one earlier than the other; the bovine *Ugandax* and possibly *Pelorovis* as well; a reduncine common at certain levels and also two rarer reduncines; the hippotragine *Praedamalis deturi*; an alcelaphine possibly allied to *Damalops* of southern Asia and two further alcelaphines; a primitive *Aepyceros*; two or more neotragines; a gazelle, and an ovibovine. Ecologically this is a well-balanced list.

None of the species is identical with any in the Shungura Formation, Omo, Ethiopia. The assemblage is likely to be earlier than those from Members C or upper B of the Shungura Formation.

The Amado bovids could be of the same age as or older than those from the Hadar Formation, although those from Geraru could be younger.

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Introduction

This account is based on fossils collected by the Afar Research Expedition 1973–77. Most of them come from the Hadar Formation on the western side of the Afar Depression at about 11° 10′N, 40° 30′S in Ethiopia. The formation consists of about 150–280 m of lacustrine and fluvial deposits in the vicinity of the Awash River and is divided into four members:

Kada Hadar Member (KH) with the tuff (KHT) at its base.
Denen Dora Member (DD), the base of which is marked by the Triple Tuff (TT) band of thin tuffs in a meter-thick bed of green argillite (CC). Above come submembers 1–3.
Sidi Hakoma Member (SH) in which the Sidi Hakoma Tuff (SHT) is succeeded by submembers 1–4.
Basement Member (BM).

A basalt within SH-4 gives a K-Ar date of around 3.0 m.y., and another at a high level in KH a date around 2.6 m.y. Palaeomagnetism is normal except for reversals at the top of SH, including the dated basalt, and the lower part of KH, beneath the dated level. These reversals are identified with the Mammoth and Kaena events within the Gauss normal epoch. The formation appears to have an age spanning 3.3–2.5 m.y. The sedimentary history is thought to show a shallow lake with a wide marginal zone from SHT to DD-1, then the transgression of a large lake with deltaic margins in the rest of DD-1 and 2, then the growth of deltas in DD-3 and KH-1. Further information on geology and dating can be found in Johanson et al. (1978), Taieb et al. (1978), and Taieb and Tiercelin (1979).

Other sites mentioned are:

Kaiso Formation, Uganda, spanning about 5.0–2.5 m.y. and having an earlier and a later faunal level (Cooke and Coryndon 1970).
Karmosit beds, Kenya, probably a little older than 3.4 m.y. (Bishop et al. 1971).
Laetoli, formerly Laetolil, Tanzania. The Laetolil Beds date from 3.59 to 3.77 m.y., and the later Ndolanya Beds are older than 2.4 m.y. (Leakey and Hay 1979).
Langebaanweg, South Africa. The E Quarry assemblage is of latest Miocene or early Pliocene age; the two minor assemblages in Baard's Quarry are younger (Hendey 1976, 1978; Gentry 1980).
Lothagam, Kenya. The Lothagam 1 fauna may be about 5.5 m.y. (Behrensmeyer 1976; Smart 1976).
Lukeino Formation, Kenya, 6.0–6.7 m.y. (Pickford 1978).

Makapansgat Limeworks, South Africa, of Pliocene age (Vrba 1977).
Mpesida Beds, Kenya, about 7.0 m.y. (Bishop et al. 1971).
Mursi Formation, Omo, Ethiopia, where a basalt overlying the fossiliferous levels has been dated to 4.05 m.y. (Butzer and Thurber 1969).
Olduvai Gorge, Tanzania, where Beds I–IV span 2.1–0.6 m.y. (Leakey 1971; Gentry and Gentry 1978).
Shungura Formation, Omo, Ethiopia, with a time span from 4.0 to 0.8 m.y. The upper part of Member B, the lowest level with bovid fossils in appreciable numbers, has an age about 2.9 m.y. and Member G an age slightly younger than 2.0 m.y. (Brown and Shuey 1976: Table 1, Fig. 6; *see also* Drake et al. 1980, Fig. 3).
Sterkfontein Type Site or Main Quarry, South Africa, where most of the mammal fossils come from Member 4, probably dating from between 3.0 and 2.5 m.y. (Vrba 1976, Fig. 20; Partridge 1978).

Two sets of deposits outside Africa are the Tatrot and Pinjor Formations of the Siwaliks Group of India and Pakistan. The first may date from about 4.0 to 2.5 m.y. and the second from 2.5 to perhaps 1.5 m.y. (Pilbeam et al. 1977; Pilbeam et al. 1979; Opdyke et al. 1979).

The following classification of bovids is used (see Gentry 1980:217):

FAMILY BOVIDAE

Subfamily Bovinae	
Tribe Tragelaphini	Eland, kudus, bushbuck and allies. Mainly browsers in bush, woodland and forest.
Tribe Boselaphini	Now represented only by the nilgai and four-horned antelope in India, but formerly occurred in Africa.
Tribe Bovini	Cattle and buffaloes, the largest bovids.
Subfamily Cephalophinae	
Tribe Cephalophini	Duikers, mainly forest antelopes, rarely fossilized.
Subfamily Hippotraginae	
Tribe Reduncini	Waterbuck, lechwes, kob and reedbucks. Grazing animals found in habitats in the vicinity of water.
Tribe Hippotragini	Roan, sable antelope, oryxes and addax.
Subfamily Alcelaphinae	
Tribe Alcelaphini	Wildebeests, hartebeests, bastard hartebeests. Grazing cursorial antelopes of open country. Also *Aepyceros*, the impala, usually placed in the Antilopini.

Subfamily Antilopinae	
Tribe Neotragini	Steinboks, dik-dik and allies. Small antelopes found in less dense cover than duikers.
Tribe Antilopini	Gazelles, springbok and allies (also *Saiga* and *Pantholops* of Asia). Small-to-medium-sized cursorial antelopes often adapted to conditions of water shortage.
Subfamily Caprinae	
Tribe 'Rupicaprini'	Goral, serow, Rocky Mountain goat. *Rupicapra* might better be placed in the Caprini. Not in Africa.
Tribe Ovibovini	Musk ox and takin. Formerly more widespread.
Tribe Caprini	Sheep, goats, tahrs.

Specimens are referred to by their field numbers, e.g., AL 116-40, which means specimen number 40 from Afar locality 116.

Horn cores are said to be *obliquely inserted* when their inclinations are low in side view. This is the opposite condition from upright insertions. A *basal pillar* may occur in the center of the medial side of the upper molars or the lateral side of the lower molars, completely or partly separate from the rest of the occlusal surface. It is the entostyle of an upper and ectostylid of a lower molar. The abbreviation *m.y.* denotes millions of years.

I thank Y. Coppens and D. C. Johanson for the invitation to work on the Bovidae from the Afar, and B. T. Gray for much practical help.

Systematics

Tribe TRAGELAPHINI

Tragelaphus aff. *nakuae* Arambourg 1941

This appears to be a fairly common species in DD-2 and 3. The best pieces are:

AL 116-12	DD-3	cranium with much of horn cores
AL 151-2	DD-3	" " " " " "
AL 174-1	DD-2	" " " " " "

The crania agree with *Tragelaphus nakuae*, well known from Members B (units 10 and 11) to H of the Shungura Formation, in overall size (about that of greater kudu, *T. strepsiceros*), in large horn cores with anteroposterior compression and a strong posterolateral keel, and in the braincase roof being almost horizontal in profile and set at a high level. There are differences, however: the horn cores are more strongly spiralled; the posterolateral keel consequently has a concave, not convex, course immediately above its base; the frontals have a less convex surface between and behind the supraorbital pits; the braincase is longer; and there is no transverse excavation across the skull roof behind the horn core insertions. In the second two of the listed specimens the insertions of the horn cores are more upright and closer together than in *T. nakuae* and the horn cores are less divergent basally than in Shungura Formation examples postdating Member B. In AL 116-12 the insertions are more divergent than in Shungura B and about as oblique as in *T. nakuae* generally.

These characters are mostly more primitive than in *T. nakuae* of Shungura Members C–G. However, the variety of *T. nakuae* occurring in the upper part of Member B does not seem to be a good transitional form and its temporal relationship to the Hadar Formation species is not clear.

The basal pillars on the lower molars of *T.* aff. *nakuae* are perhaps not so well developed as one would like to see in a putative ancestor of *T. nakuae.*

Tragelaphus aff. *nakuae* horn cores differ from those of a *Tragelaphus* in the Mursi Formation, which possibly belong to a kudu, by larger size, less outwards curvature as they pass upwards, a stronger posterolateral keel, and an anterior keel which is positioned centrally rather than laterally on the front surface and is perhaps weaker.

Tragelaphus sp. nov.

This species is confined to SH-2 and was evidently replaced after an interval by *Tragelaphus* aff. *nakuae* in DD-2. The best pieces are:

AL 127-29	SH-2	cranium and much of horn cores
AL 128-9	″	frontlet and horn cores
AL 142-3	″	cranium ″ ″ ″ (Plate 1)

Among the species' distinctive features are long horn cores lacking keels proximally but with an anterior keel and a stronger posterolateral keel distally. The horn cores show a little mediolateral compression at their bases as in *T. strepsiceros*. Compared with *T.* aff. *nakuae* their insertions are more upright and closer to the orbits, their course is more openly spiralled, and the surface texture is rougher near the base. Other characters are that the braincase roof is more inclined and the temporal ridges weaker than in *T.* aff. *nakuae*. The anterior tuberosities are very strong on the basioccipital, almost certainly more so than in *T.* aff. *nakuae*. Basal pillars on the lower molars are probably better developed than in *T.* aff. *nakuae* but less marked than in Shungura *T. nakuae*. The P_4 hypoconid projects

Plate 1. *Tragelaphus* sp. nov. Anterodorsal view of cranium and horn cores, AL 142-3.

strongly and its metaconid is situated relatively posteriorly and well separated from the paraconid, all of which differ from *T.* aff. *nakuae.*

This species may not be so totally different from other tragelaphines as its horn cores at first sight suggest. It could be a normal archaic tragelaphine, much like an undescribed cranium from the Ndolanya Beds, Laetoli, or like the surviving *T. buxtoni* except in its two specializations of mediolateral compression and loss of keels on its horn cores. The same two characters later come to be found separately in *T. strepsiceros* and *T. imberbis*, respectively.

Tribe BOVINI

Ugandax sp. nov.

The common bovine of the Hadar Formation is an advanced *Ugandax* represented by several major pieces:

AL 107-1	SH-3	skull with left horn core
AL 116-17	DD-3	cranium with much of horn cores
AL 116-40	DD-3	partial frontlet and horn cores, possibly subadult
AL 127-2	SH-2	cranium with much of horn cores
AL 173-2	DD-2	right horn core and much of frontal
AL 194-1	DD-1	skull with horn cores

Ugandax gautieri, known by the holotype skull (Cooke and Coryndon 1970, Plates 17, 18) from Kaiso Formation deposits of unknown age in the Kazinga Channel, is the type species of *Ugandax* and was thought by Gentry and Gentry (1978:320–322) to be near the ancestry of *Syncerus*. It shares with other primitive bovines its fairly large size; a skull less low and wide than in living bovines; horn cores short-to-moderately long and with almost no compression; braincase short and with a slightly inclined roof; strong temporal ridges; triangular basioccipital; small supraorbital pits and little or no indication of a preorbital fossa. The horn cores show irregular development of keels.

The new species differs from *U. gautieri* by a lower and wider cranium, and by horn cores which are sometimes a little compressed mediolaterally in their lower parts, inserted perhaps further behind the orbits and more widely apart, less backwardly curved in side view, and more divergent. The temporal ridges are wider apart posteriorly, the braincase shorter, anterior tuberosities closer on the basioccipital, and the central longitudinal ridge of the basioccipital less pronounced. It is possible that divergence of the horn cores is stronger and the median vertical occipital ridge better developed in the DD examples, and there is also a good deal of variation not obviously related to the stratigraphic succession.

It is *Syncerus* and not *Ugandax* which occurs in the Shungura Formation. Horn cores of *S. ?acoelotus*, mostly from Member C, emerge nearly transversely from the skull and scarcely pass at all backwards. They have a flattened dorsal surface. An immature skull from Member B unit 12 has horn cores still passing backwards but with greater basal divergence than the Hadar horn cores.

As far as tooth characters are concerned, two of the bovine P_4s (that on the left mandible, AL 116-35 DD-3, and another left one, AL 182-72 DD-2) look more primitive than in bovines from the upper part of Member B of the Shungura Formation in that the metaconid is aligned more diagonally and less transversely. Others (four from DD-2, one from DD-3, and one from SH-2) look as advanced as in Shungura Member B. The single bovine mandible, 1936A, from the Sterkfontein Type Site (Vrba 1976:47, Plate 26B) has an unerupted P_4 which again compares well with Shungura Member B and the majority of Hadar Formation examples.

A left mandible, AL 165-10 from SH-2, looks more primitive than other Hadar Formation Bovini. It retains P_4–M_2, most of M_3 and sockets for P_2 and P_3 and is in early middle wear. It appears primitive in the lack of localized constrictions of the lateral lobes of the lower molars and in the poorly localized ribs on the medial walls of the molars between the stylids. These features resemble *Parabos*, a primitive bovine of the European pre-Villafranchian Pliocene. Other pieces from SH-2 do not look so primitive, but it may still be noted that *Parabos*-like dentitions do not occur in higher members of the Hadar Formation.

?Pelorovis sp.

A piece of horn core, AL 114-1C from DD-2, is about 220 mm long and looks as if it could belong to *Pelorovis* (long-horned buffaloes of the Plio-Pleistocene) or to the older and possibly ancestral *Simatherium*. It is curved in one plane, has no keels, and is compressed, the greatest diameter at its lower end being 72 mm and the diameter at 90° to that one being 57 mm. Remains of an internal sinus at the thicker end suggest that the horn core may be largely complete and may have had a total length scarcely more than 300 mm. It is too incomplete for its insertion position on the skull to be ascertained and its identification must remain tentative.

Tribe REDUNCINI

Kobus sp. A

In the Hadar Formation Reduncini first appear in SH-3 and are mostly found in submember DD-2. They continue in DD-3 but there they constitute a lower proportion of the whole bovid fauna. There are some crania, e.g., AL 157-4 DD-3, and numerous horn cores. Their size is about that of a kob. The horn cores are long and are compressed anterolaterally to posteromedially. They have no keels and poor-to-absent transverse ridges. Their divergence is quite strong and increases toward the tips; they have little or no backward curvature, are inserted fairly uprightly and may even curve forward from base to tip. Temporal lines on the cranial roof are not prominent and approach closely posteriorly. The occipital surface is rather flat, faces wholly backwards, and is without a smoothly rounded edge; its sides may even be concave upwards. Narrow mastoids lie within the boundaries of the occipital surface, the auditory bulla is inflated but not large, and the braincase is wide rather than high.

There is some puzzling variation in horn core morphology, best exemplified by the pair AL 155-7H from DD-2. They are not quite so long as others; their compression is less clearly anterolateral to posteromedial and more nearly lateral to medial; there is more of a posterolateral keel; divergence is perhaps less and does not increase so much toward the tips; and forward or upward curvature is more distal. Three more specimens agree in these characters and it is doubtful whether they are a separate species from the 14 or so others. Probably they are not.

The Hadar horn cores seem close to a species from Member B units 10 and 11 of the Shungura Formation. This also shows long horn cores with a degree of anteroposterior compression, increasing divergence distally, and little or no backward curvature. However, the Hadar species has anterolateral to posteromedial rather than anterior to posterior compression of the horn cores; the braincase roof is more inclined in profile and the occipital edge less rounded.

An interesting feature of reduncine teeth from the Hadar Formation is that the paraconid on P_4 extends backwards, grows very close to the metaconid and perhaps even fuses with it (Fig. 1). This state cannot be found in other Plio-Pleistocene Reduncini, including those of the Siwaliks or Shungura upper Member B. Something similar can be seen in extant *Redunca arundinum*, but here it is forward growth of the metaconid which may be more important in bringing the two cusps together. It may also be noted that the premolars of Hadar reduncines form a longer row than in extant forms and the molar teeth are less high crowned.

Kobus sp. B

Another reduncine species is represented by a pair of horn cores AL 208-8 from SH-3. They are quite short, a little compressed, with a flattened area on the lateral surface, strong transverse ridges, strong backward curvature, and poor divergence which lessens distally. This species is earlier than nearly all the *Kobus* sp. A in the Hadar Formation. Either it became extinct, at least locally, or it may have been related to the persistent but ever-changing lineage leading to the extant kob.

Kobus sp. C

AL 130-2, possibly from SH, is the proximal part of a horn core with part of the frontal. It is not unlike *Kobus porrecticornis* (Lydekker 1878), a

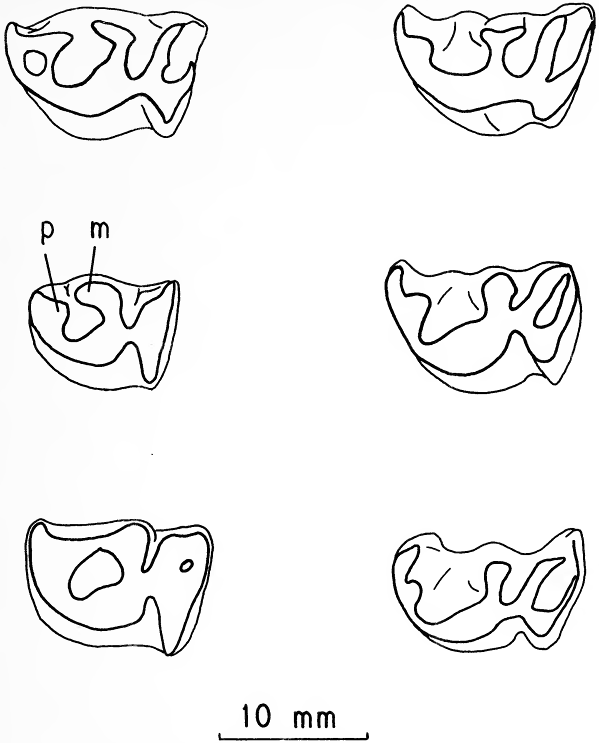

Fig. 1. Reduncini P$_4$s, all shown as of the left side and with the anterior side toward the left of the figure. Left column, from the top: Hadar Formation, AL 153-3 DD-2, early middle wear; AL 167-5 DD-2, middle wear; AL 156-1A (reversed) DD-3, late middle wear. Right column: Shungura Formation, L 2-46B Member B, early middle wear; F161-39 (reversed) Member H, middle wear; F256-18 Member H, early middle wear. Paraconid (*p*) and metaconid (*m*) approach more closely in the Hadar examples.

small, kob-like reduncine from the upper part of the Dhok Pathan and/or the Tatrot Formation of the Siwaliks, the Mpesida Beds (H. Thomas, personal communication, 1977), Lukeino Formation and Baard's Quarry at Langebaanweg (Gentry 1980: 321–323). This horn core, however, has transverse ridges, hardly any backward curvature (probably less than in *K.*

porrecticornis), was probably inserted more widely from its partner of the other side, and the supraorbital foramen is small (unless what is preserved is only the rearmost of a line of foramina).

Tribe HIPPOTRAGINI

Praedamalis deturi Dietrich 1950

Two horn cores, seemingly of this species, are known from the Hadar Formation:

AL 188-4	DD-2 or 3	much of a nearly straight left horn core with part of the orbit (Plate 2)
AL 154-11	DD-3	basal part of a horn core

This species was described from Laetoli by Dietrich (1950:30, Plate 2, Fig. 23) and discussed by Gentry and Gentry (1978:351) who referred it to the Hippotragini. It occurs in the Laetolil Beds at Laetoli according to collections made by M. D. Leakey since 1974. No teeth from the Hadar Formation look hippotragine.

Tribe ALCELAPHINI

?Damalops sp.

Among the best preserved remains are:

AL 208-7	SH-3	most of skull with horn cores
AL 310-18	—	cranium with base of right horn core
AL 353-3	SH-2	cranium with much of left horn core
AL 161-5	DD-3	cranium with partial base of left horn core
AL 320-1	DD-3	part of cranium, pieces of horn core, cervical vertebrae
AL 120-2	DD-3	horn cores and much of an associated skeleton

There are also a large number of horn cores. The absence of face lengthening and of extreme braincase shortening, and the presence of large preorbital fossae are different from extant alcelaphines.

Most of the horn cores are from DD-2 and 3 and show fairly upright insertions, curvature that is upward and forward from the base, divergence gradually increasing from the base, often a swollen basal area reminiscent of *Connochaetes*, and a cross-sectional shape that is squared off posteromedially at the base. The horn cores on the earlier skull AL 208-7 are less curved and less divergent. Moreover, their divergence does not increase continuously but changes fairly sharply at a point about one third of the distance above the base. Other horn cores from SH are curved, however,

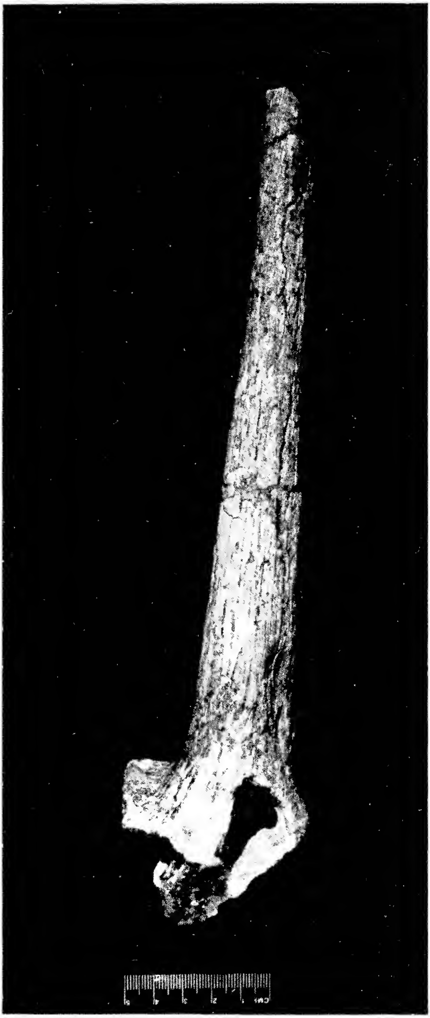

Plate 2. *Praedamalis deturi.* Anterior view of left horn core, AL 188-4.

and it can only be noted that no relatively straight horn cores occur above SH. Possible evolutionary changes may be seen at the back of the skull. In AL 208-7 and AL 353-3 from SH the junction between the base of the nuchal crest and the back of the zygomatic arch is placed rather anteriorly, and each half of the occipital surface faces partly laterally as well as backwards. In the stratigraphically higher cranium AL 161-5 and in AL 310-18 the junction of nuchal crest and zygomatic is more posterior and the occipital surface faces more wholly backwards.

Alcelaphine teeth of the Hadar Formation are probably less hypsodont than in living species; on the upper molars the central cavities are less complicated, the ribs less prominent in relation to the styles, and the medial lobes perhaps less rounded. On lower molars the central cavities are less curved and the medial walls perhaps less outbowed. The rear part of P_4 (hypoconid, entoconid, and entostylid) is less reduced, and the valley between the entoconid and entostylid is perhaps oriented more transversely to the line of the jaw. These primitive features are less clear in relation to alcelaphines of the Shungura Formation and Olduvai Beds I–IV.

It is difficult to classify the Hadar alcelaphine. Compared with *Parmularius* sp. in the Laetolil Beds (Gentry and Gentry 1978:382, Plates 21, 22, Fig. 2) it is larger and its horn cores show distal divergence but not backward curvature. It could be conspecific or closely related to a partial cranium 1959.233 (Gentry and Gentry 1978, Plate 22, Fig. 1) from the Laetolil or Ndolanya Beds, and it could at the same time be a close relative of *Damalops palaeindicus* (Falconer 1859) from the Pinjor Formation and Tadzhikistan, USSR (Dmitrieva 1977). This is on the basis of such similarities as: overall size (about that of extant *Alcelaphus*); high and narrow skull; horn cores inserted closely and not very uprightly above the backs of the orbits, nearly parallel proximally but increasingly divergent distally; frontals raised between the horn bases but not tremendously so; braincase rather long by comparison with presumed later alcelaphines; braincase roof inclined and with little sign of a parietal boss; preorbital fossa large; nasals pronouncedly narrow as a ridge between the preorbital fossae; and a deep face. However, *D. palaeindicus* shows backward curvature of its horn cores, horn cores not tapering rapidly above the base, sides of the braincase parallel and not widening posteriorly, and probably also longer horn cores, shorter braincase, and a tooth row positioned more anteriorly. P_2 is absent on the only two Hadar specimens (both in middle wear) on which its state is determinable, and this contrasts with its presence on a single *D. palaeindicus*.

Alcelaphini sp. 2

A separate smaller alcelaphine species is represented by a badly preserved cranium with left horn core AL 146-1 SH-2. This is like the *Parmularius* sp. from the Laetolil Beds, but it differs in stronger mediolateral compression and more oblique insertions of its horn cores, less of a *Parmularius*-like boss on its cranial roof, a wider braincase and basioccipital, and a nuchal crest which is not concave upwards.

Alcelaphini sp. 3

AL 209-1 from SH-3 is a problematical lower part of an alcelaphine horn core which is not complete enough to be oriented. It curves in one plane and is compressed in the plane at 90° to this plane. Its shape is somewhat like a Geraru species represented by AL 94-1, but it lacks the deep longitudinal grooving of that species.

Aepyceros sp.

Aepyceros is well represented in SH and is proportionately more common there than in DD. There are also two horn cores and a tooth in BM. The best pieces are:

AL 127-3	SH-2	most of left horn core but with much of the pedicel eroded
AL 173-7	DD-2 or 3	much of left horn core, pedicel, dorsal orbital rim and part of left frontal
AL 132-2	SH-1	right maxilla with P^4–M^3 in early middle wear
AL 199-6	SH-1	right mandible with P_4–M_3 in early middle wear

Horn cores in SH differ from *Aepyceros* of the Shungura Formation by their smaller size and by being shorter, less curved backwards and less lyrated, all these features being apparently primitive. Lyration may be slightly stronger in DD horn cores, i.e., divergence may be greater just above the base (but without equalling that of Shungura examples), but DD horn cores are less complete and the horn core AL 142-4 from SH-2 is not different from those in DD. Two DD horn cores have postcornual fossae smaller than in a single SH example.

The SH horn cores differ from some in the Mursi Formation, Omo, by being slightly smaller, having stronger transverse ridges, less backwards curvature (chiefly shown by the distal parts being recurved upwards), and less accentuated posterior grooving. The DD ones also differ by their enhanced lyration so far as it is a valid character.

The two horn cores from BM, AL 124-21 and -40, the latter being without its basal part, may derive from the same individual. They are perhaps more mediolaterally compressed than SH specimens, and total curvature (backward curvature plus reduction in divergence distally) is probably less. Indeed, they might not have been regarded as *Aepyceros* at all had not internal sinuses been visible low in the pedicel of AL 124-21. The postcornual fossa of AL 124-21 is larger than in DD specimens.

The upper cheek teeth of Hadar Formation *Aepyceros* have better styles than in the Shungura *Aepyceros* and this is best seen with the mesostyles of the molars. P_4 has less frequent paraconid-metaconid fusion and dP_4 has at least a rear basal pillar.

A proximal femur, AL 122-8 DD-2, is probably of *Aepyceros*. It is interesting in that the lateral parts of the articular head are somewhat narrow anteroposteriorly and the notch between articular head and great trochanter is not very deeply excavated, i.e., it is less distinctive overall than the same bone in extant *Aepyceros*.

Tribe NEOTRAGINI

Madoqua ?avifluminis Dietrich 1950

Neotragini are rare in the Hadar Formation. A right horn core, AL 55-25 from KHT, appears to be more akin to *Madoqua ?avifluminis* from the Ndolanya Beds than to *M. avifluminis* itself which is from the Laetolil Beds.

?Raphicerus sp.

Some neotragine dental remains are too large for *Madoqua*. Several pieces, perhaps from SH-1, belong to a species about the size of extant *Raphicerus* or *Dorcatragus*. An upper molar among them is low-crowned for a neotragine. An M^2 and M^3 in a right maxilla, AL 167-6 DD-2, are similarly low-crowned but perhaps smaller. A mandible, AL 269-2 DD-3, has rather worn teeth. The molars on the mandibles have basal pillars.

?Neotragini sp. indet.

AL 211-2 from SH-4 or DD-1 is a left M^3 in early wear which is larger than the teeth just discussed but smaller than Antilopini in the Hadar Formation. It is not very hypsodont and has a strong anterior rib. It agrees with extant *Ourebia* except in its larger size and the prominence of its metastyle lower down. It differs from the tooth of a small reduncine, YS 4-12, in the Mursi Formation by its larger size and weaker styles.

Tribe ANTILOPINI

Gazella sp.

An unnumbered horn core from AL 333 in DD-2 or 3 is probably from the right side of a *Gazella*. The pedicel is missing and it is incomplete at the tip. Its total length might have been about 130 mm, which is rather short for a gazelle. It has strong mediolateral compression, less backward curvature than Shungura Formation gazelles, and the level of greatest transverse width of cross section is sited nearly centrally as in both Shungura and Olduvai fossil gazelles.

Some dental remains are too small to fit *Aepyceros*. Among them is AL 127-1 SH-1, a left maxilla with P^3–M^1 on which the P^4 has a rib between the styles (albeit less pronounced than the rib on P^3).

Some antilopine limb bone parts from AL 132 in SH-1 include an interesting metacarpal AL 132-10. This has a posterior surface more hollowed proximally than at the present day, and it is neither shorter nor thicker than in extant gazelles (Fig. 2). It therefore contrasts with *Antidorcas* from Olduvai Gorge (Gentry and Gentry 1978:430, Fig. 33).

Tribe OVIBOVINI

Ovibovini sp. aff. "*Bos*" *makapaani* Broom

A single skull, AL 136-5 (Plates 3 and 4) from the middle or upper Hadar Formation, with horn cores, cranium, much of the face and the left M^3 in middle wear, is of an ovibovine. Among its chief features are that the large but probably short horn cores are compressed posterodorsally to anteroventrally and emerge transversely from very elevated frontals; the short braincase has a steep roof; and the basioccipital is triangular, has a central longitudinal groove which does not widen posteriorly, and has anterior tuberosities with long, sharp ridges converging anteriorly.

Ovibovine horn cores or teeth are known in Africa as late as the early Pleistocene (Gentry 1978:561). The best known species is *Makapania broomi* Wells and Cooke (1956) from Makapansgat Limeworks and probably from Sterkfontein Type site (teeth which Vrba [1976:48] referred to *M.* cf. *broomi*), which Gentry (1970) held to be related to *Megalovis latifrons* of the later Villafranchian of Europe. The Hadar form is like *Maka-*

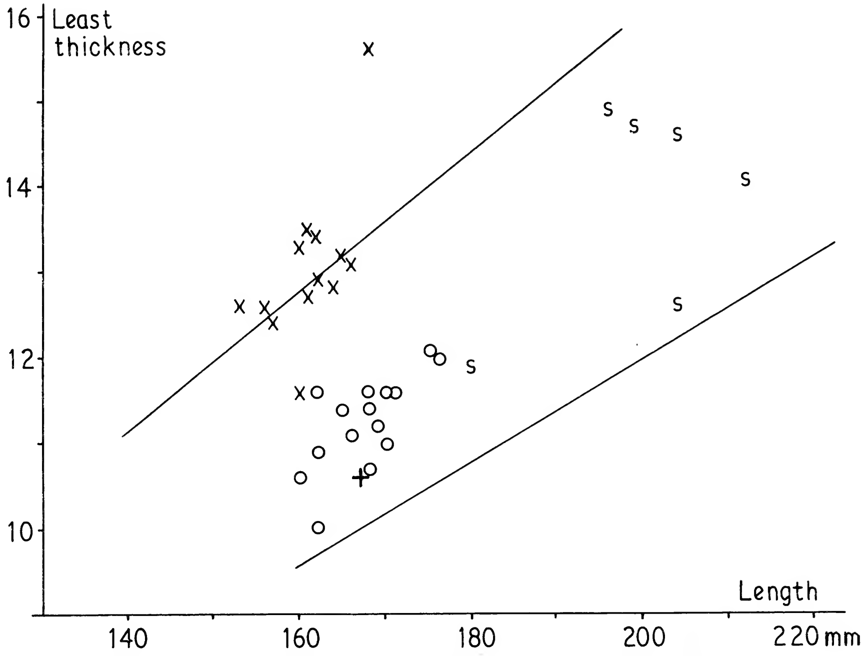

Fig. 2. Length and least mediolateral shaft thickness of metacarpals of some Antilopini. X = *Antidorcas recki*, left sides, from site FLKN, Bed I Olduvai Gorge; S = extant springbok, *A. marsupialis*; O = extant *Gazella thomsoni*; + = Hadar Formation left metacarpal AL 132-10. The upper diagonal line is that along which least thickness is 8 percent of length; the lower line is for 6 percent.

Plate 3. Ovibovini sp. aff. "*Bos*" *makapaani*. Dorsal view of skull and horn cores, AL 136-5.

pania broomi in the course and wide divergence of its horn cores and in its projecting orbital rims, but differs in that its horn cores are more massive and probably shorter; their compression becomes more dorsoventral immediately above the base instead of disappearing; the frontals rise much higher so that the cranial roof is very inclined; the anterior part of the zygomatic arch is thicker below the orbits; and the longitudinal groove of the basioccipital persists further anteriorly and does not widen posteriorly.

The Hadar ovibovine is actually much more similar to "*Bos*" *makapaani* Broom (1937) from deposits of unknown age in Buffalo Cave (Cooke 1952:33) near Makapansgat. It is known by a frontlet and horn cores and has never been adequately described. It appears to differ from the Hadar ovibovine only in being slightly smaller and having more compression of its horn cores.

Plate 4. Ovibovini sp. aff. "*Bos*" *makapaani*. Lateral view of skull and horn cores, AL 136-5.

At present it looks as if two distinct lineages of ovibovine, have been present in Africa, these being the Hadar Formation and Buffalo Cave stock on the one hand and *Makapania broomi* on the other.

Bovidae from Amado

Bovids have come from three localities at Amado. The first locality, AL 100, has the most bones and six species are represented.

AL 100

A frontlet, teeth and postcranial remains belong to a species smaller than the *Tragelaphus* aff. *nakuae* of the Hadar Formation. The horn cores on the frontlet are long, anteroposteriorly compressed about as much as in Pliocene or Miocene *Tragelaphus*, strongly curved in a lyrate course, having the posterolateral keel better marked than the anterior keel, and inserted above the back of the orbits. They are very like a somewhat larger, as yet undescribed *Tragelaphus* from the Ndolanya Beds at Laetoli. There is some resemblance of both these forms to *T. buxtoni* of the Ethiopian highlands, probably because the latter is a relict species with some primitive characters. The teeth are about the size of the extinct kudu *T. gaudryi* in the Shungura Formation, although the premolars may have been slightly larger. On P_4 the paraconid and metaconid approach but do not join together. A bovine species is represented by some rather low crowned, mostly upper, teeth. A right metatarsal and perhaps a few other postcranial bones can also be identified as bovine. Two alcelaphine teeth appear to come from different-sized species. Four pieces of *Aepyceros* horn cores differ from those in the Hadar Formation by being larger, probably longer, with stronger lyration and with better-marked transverse ridges. They look like *Aepyceros* from the Shungura Formation. A dozen or more teeth, which are probably conspecific with the horn cores, are larger than *Aepyceros* teeth from either the Hadar or Shungura Formations and are probably less high crowned than in the Shungura Formation. Three postcranial bones may also belong to *Aepyceros*. A left upper molar in early middle wear and an unassociated astragalus could belong to the Antilopini.

AL 99

From a second locality, AL 99, come two pieces of mandible, probably from the same individual, with tragelaphine teeth about the size of the species at AL 100, and one or two postcranial bones which could be of the same species.

Two horn cores, a left and a better-preserved right, belong to a small reduncine, apparently *Kobus porrecticornis* (see under *Kobus* sp. 3). A complete and a fragmentary alcelaphine mandible represent a smaller and a larger species as at AL 100. Two horn cores, probably from the same individual, belong to *Gazella janenschi*. They have a slight flattening of the lateral surface and are not closer either to the pattern seen in examples from the Laetolil or Ndolanya beds at Laetoli.

Two pieces of a single medium-sized horn core, AL 99-6, are distinctive but unidentified. The horn core is compressed, perhaps from side-to-side, and curves, perhaps backwards. It is also a little curved along an axis at right angles to the main curvature. There are no keels or transverse ridges but there is a noticeable groove along its most convex edge. There was a sinus in its pedicel. The insertion position was unknown.

AL 104

Only two bovids come from the last Amado locality, AL 104. A large tragelaphine is represented by a frontlet, a mandible, and possibly a scapula. The frontlet is most similar to the cranium AL 116-12 of *Tragelaphus* aff. *nakuae* from the Hadar Formation. This species is larger than the tragelaphine at AL 100. What is presumably a bovine is represented by the stem of a large scapula.

Bovidae from Geraru

Bovid fossils from Geraru were available from localities AL 70, 72, 73, 83, 86, 87, 88, 90, 92, and 94. The main pieces are as follows:

Tragelaphus nakuae

This is represented by a left horn core AL 83-2. It best resembles fossils of this species from Shungura Formation Members C to F. A right M_3 and probably an astragalus are also tragelaphine and perhaps of this species.

Syncerus sp.

This is represented by a damaged partial cranium AL 70-6 with strongly divergent horn cores which are compressed in the dorsoventral rather than the mediolateral plane. Both characters suggest *Syncerus* rather than *Ugandax*. A left maxilla of a bovine comes from the same locality.

?Hippotragini sp.

A left M_3 AL 70-5 may be of a hippotragine, larger than reduncine teeth from Geraru and low crowned compared with teeth of extant hippotragines.

Reduncini

Reduncini are represented by a number of teeth, perhaps slightly larger and more hypsodont than in the Hadar Formation. A short right horn core, AL 74-7, is somewhat like *Kobus subdolus* of Langebaanweg (Gentry 1980) but the teeth are not. One or two postcranial bones are rather doubtfully taken as reduncine.

Alcelaphini spp.

AL 83-4 is a much-damaged horn core possibly of the left side. It is somewhat like the horn cores of the small primitive *Parmularius* from the Laetolil Beds (Gentry and Gentry 1978:382, Plates 21, 22, Fig. 2) or the horn core L 292-29 from Member C of the Shungura Formation which may belong to *Parmularius* or to the *Damaliscus niro* lineages.

Alcelaphine teeth of two different sizes are known from several Geraru sites and must represent different species. In addition there is a right M_3 in middle wear, AL 87-1, with occlusal length 22.3, which is a little smaller again and may belong to a third species. It is a little larger than the Hadar or Amado *Aepyceros*, and differs by having central cavities with more of a typically alcelaphine outline, medial walls with well-rounded lobes, and lateral lobes which are not very pointed.

Bases of two *Aepyceros* horn cores agree in size and morphology with Amado rather than Hadar Formation examples.

A distinctive species, possibly alcelaphine, is represented by parts of left and right horn cores and a separate partial cranium, AL 94-1. The left horn core is long, anteroposteriorly compressed basally, with transverse ridges, inserted above the back of the orbits and close to the midline of the frontals, strongly divergent in its central part but without backward curvature, with irregular but deep longitudinal grooves mainly on the lower part of the medial side, and having sinuses within the frontals and a large one in the horn pedicel. The frontals between the horn core bases are at a higher level than the dorsal part of the orbital rims. The braincase was probably short; its roof is inclined. The temporal lines approach fairly closely at the back of the braincase roof. The occipital surface is rather low and wide with a strong median vertical ridge leaving each half facing partly laterally as well as backwards. The sulci on the internal wall of the braincase appear more similar to four Shungura examples of *Kobus* and *Menelikia* than to alcelaphines, yet the occipital surface is more like alcelaphines than a reduncine. The close insertions of the horn cores are unlike *Connochaetes* or *Oreonagor* (Thomas 1884, Plate 7, Fig. 1), but *Beatragus* could be related. Another possible relationship is to *Makapania*, already mentioned in the account of the Hadar ovibovine. The basal compression and course of the horn cores as well as their insertion position are all similar. The transverse ridges distally and the longitudinal grooving basally are different, however.

Discussion

The species list for bovids of the Hadar Formation is given in Table 1. It is a well-balanced list in which nearly all tribes of bovids are represented. Such a list can be compared with present-day African faunas. The first two entries are successive large tragelaphines that might correspond ecologically to kudus (*Tragelaphus strepsiceros* or *imberbis*) or nyala (*T. angasi*). Two bovines were present as was also usual into the Pleistocene, and the *Pelorovis* was the rarer of the two as in the Shungura Formation. A larger reduncine and a rare smaller one may have had differing ecologies like waterbuck and kob or like lechwe and reedbuck. A hippotragine would correspond to *Hippotragus* or *Oryx*. A larger and a smaller alcelaphine

TABLE 1
Species List for Bovids of the Hadar Formation

	SH	DD	Other
Tragelaphus aff. *nakuae*		X	
?*Tragelaphus* sp.nov.	X		
Ugandax sp.nov.	X	X	
?*Pelorovis* sp.		O	
Kobus sp. A	O	X	
" " B	O		
" " C			possibly SH
Praedamalis deturi		O	
?*Damalops* sp.	X	X	
Alcelaphini sp. 2	O		
" " 3	O		
Aepyceros sp.	X	X	also BM
Madoqua ?*avifluminis*			KH
?*Raphicerus* sp.	O		
?Neotragini sp.indet.			unknown
Gazella sp.		O	
Ovibovini sp.aff.“*Bos*” *makapaani*			middle or upper Hadar Formation

(X = abundant, O = less common)

were present but did not include *Connochaetes* or any apparent relatives. Impala, dik-dik, one or more other neotragines, and a gazelle can all be found at the present day although the impala does not now occur so far north. The ovibovines are extinct in Africa, probably since the early Pleistocene. The list does not show a preponderance of Alcelaphini (other than *Aepyceros*) as at Olduvai Gorge, or of Tragelaphini, Reduncini and *Aepyceros* as in the Shungura Formation. The common *?Damalops* and rarer neotragines and gazelle suggest open or fairly dry conditions, while the bovine, reduncine, and *Aepyceros* suggest that water was available and scrub was present.

It is possible to analyze the bovids at a finer subdivision of the stratigraphic levels, as has been done in outline for the whole fauna by Johanson et al. (1978:557) who make the interim suggestion of three faunal units: a lower in SH-1 and 2, a middle in upper DD-1 and 2, and an upper in DD-3 and KH-1. Most fossils of the lower unit come from near the base of SH-2. Table 2 shows the distribution of bovids in more detail, and one can deduce from it the degree of support given by bovids for the suggested faunal units. The few bovid remains in SH-1 and below are nearly all *Aepyceros*. In SH-2 there is *?Tragelaphus* sp. nov., *Ugandax*, *?Damalops*, and much *Aepyceros*. SH-3 has few remains but reduncines make their first appearance here. SH-4 to DD-1 are practically barren of bovids. DD-2, containing the middle faunal unit, has the most abundant bovid fauna; common elements are *Tragelaphus* aff. *nakuae*, *Ugandax*, *Kobus*, *?Damalops*, and *Aepyceros*. More than a third of the identified bovids at this level belong to *Kobus*. In DD-3, with the upper faunal unit, the proportion of *Kobus* and *Aepyceros* appears to drop and *?Damalops* to increase.

The evidence of the Hadar Formation bovids for faunal correlations with other sites can be summarized as follows:

Tragelaphus aff. *nakuae* of DD appears to date from before Shungura C-D.

The absence of a boselaphine suggests a later age than Langebaanweg E Quarry or Lothagam Member 1.

Ugandax of SH and DD fits an age no later than Shungura upper B and probably earlier.

The main *Kobus* species found in DD is similar to but not conspecific with a species in Shungura upper Member B. The interesting conformation of the reduncine P_4 at Hadar is not known at all from the Shungura Formation or from Pleistocene and Recent reduncines. Either it is a local development or it indicates an earlier level of reduncine evolution.

Praedamalis deturi from DD is also found in the Laetolil Beds, Laetoli.

TABLE 2

Distribution of Bovids of the Hadar Formation

	BM	SHT	SH-1	SH-2	SH-3	DD-1	DD-2	DD-3	KHT	KH-3	Level unknown
Tragelaphus aff. *nakuae*							X	X			
?*Tragelaphus* sp. nov.				X							
Ugandax sp. nov.			O	X	O	O	X	X			
?*Pelorovis* sp.							O				
Kobus sp. A					O		X	X			
Kobus sp. B					O						
Kobus sp. C											O
Praedamalis deturi							?	O			
?*Damalops* sp.			O	X	X		X	X		O	
Alcelaphini sp. 2				O							
Alcelaphini sp. 3					O						
Aepyceros sp.	O	O	X	X	O	O	X	O			
Madoqua ?avifluminis									O		
?*Raphicerus* sp.			O				O	O			
?Neotragini sp.indet.											O
Gazella sp.			O				O				
Ovibovini sp.											O

(X = 5 or more specimens, O = less than 5 specimens)

?Damalops from SH and DD is not related to the well-known Pliocene and Pleistocene *Parmularius*. Its primitive characters suggest an age well before Olduvai Bed I. It has some likeness to alcelaphines from the Pinjor Formation and from an unknown horizon at Laetoli.

Aepyceros horn cores suggest that the Hadar Formation as high as DD predates upper Member B of the Shungura Formation, but their temporal relationship to those of the Mursi Formation is not clear. The latter look advanced in having more curvature but they also have weaker transverse ridges. This combination warns against taking too simple a view of character changes in space and time.

A neotragine horn core from KHT is like horn cores from the Ndolanya Beds at Laetoli.

Radiometric and palaeomagnetic dating suggest an equivalence in age between the Hadar Formation and Members C and upper B of the Shungura Formation. It is therefore interesting that among the bovids *Tragelaphus* aff. *nakuae*, *Ugandax* and *Aepyceros* of the Hadar Formation look more primitive, and by implication, earlier than their counterparts in Shungura C, C, and upper B respectively. Reduncine P_4s are also not the same as in the Shungura Formation, and they are probably at an earlier evolutionary level. While it is conceivable that contemporaneous species could differ in characters that cause one to look more primitive than another, it is noteworthy that it is always the Hadar form which looks primitive. Moreover, the only other Hadar bovid to offer a clue for faunal correlation is *Praedamalis deturi*, which again suggests an older age than Shungura upper Member B.

The Amado bovids give the impression of being Pliocene or older with the archaic-looking *Tragelaphus*, *Kobus porrecticornis*, and *Gazella janenschi*, and with the low crowned teeth of the bovine and *Aepyceros*. The large size of the *Aepyceros* horn cores goes against this judgment, however. The Geraru bovids offer fewer clues about age but could be younger than the Hadar Formation since *Tragelaphus nakuae* and *Syncerus* are present.

References

Arambourg, C. Antilopes nouvelles du Pléistocène ancien de l'Omo (Abyssinie). Bull. Mus. natn. Hist. nat. Paris. Ser. 2, 13:339–347; 1941.

Behrensmeyer, A. K. Lothagam Hill, Kanapoi, and Ekora: a general summary of stratigraphy and faunas. Coppens, Y.; F. C. Howell; G. Ll. Isaac; R. E. F. Leakey eds. Earliest man and environments in the Lake Rudolf basin. Chicago: University of Chicago Press; 1976:163–170.

Bishop, W. W.; G. R. Chapman; A. Hill; J. A. Miller. Succession of Cainozoic vertebrate assemblages from the Northern Kenya Rift Valley. Nature Lond. 233:389–394; 1971.

Broom, R. Notices of a few more new fossil mammals from the caves of the Transvaal. Ann. Mag. nat. Hist. London. Ser. 10, 20:509–514; 1937.

Brown, F. H.; R. T. Shuey. Magnetostratigraphy of the Shungura and Usno Formations, lower Omo valley, Ethiopia. Coppens, Y.; F. C. Howell; G. Ll. Isaac; R. E. F. Leakey eds. Earliest man and environments in the Lake Rudolf basin. Chicago: University of Chicago Press; 1976:64–78.

Butzer, K. W.; D. L. Thurber. Some late Cenozoic sedimentary formations of the Lower Omo basin. Nature Lond. 222:1138–1143; 1969.

Cooke, H. B. S. Quaternary events in South Africa. Leakey, L. S. B. ed. Proc. panafr. Congr. Prehist.; 1947. Oxford: Oxford University Press; 1952:26–36.

Cooke, H. B. S.; S. C. Coryndon. Pleistocene mammals from the Kaiso Formation and other related deposits in Uganda. Leakey, L. S. B.; R. J. G. Savage eds. Fossil Vertebr. Afr. 2:107–224. London: Academic Press; 1970.

Dietrich, W. O. Fossile Antilopen und Rinder Äquatorialafrikas. Palaeontographica Stuttgart 99A:1–62; 1952.

Dmitrieva, E. L. Tajikistan's and India's fossil Alcelaphinae. J. Paleont. Soc. India 20:97–101; 1977.

Drake, R. E.; G. H. Curtis; T. E. Cerling; B. W. Cerling; J. Hampel. KBS Tuff dating and geochronology of tuffaceous sediments in the Koobi Fora and Shungura Formations, East Africa. Nature Lond. 283:368–372; 1980.

Falconer, H. Descriptive catalogue of the fossil remains of Vertebrata . . . in the museum of the Asiatic Society of Bengal. Calcutta; 1859.

Gentry, A. W. Revised classification for *Makapania broomi* Wells and Cooke (Bovidae, Mammalia). Palaeont. afr. Johannesburg 13:63–67; 1970.

Gentry, A. W. Bovidae. Maglio, V. J.; H. B. S. Cooke eds. Evolution of African mammals. Cambridge, Mass.: Harvard University Press; 1978:540–572.

Gentry, A. W. Fossil Bovidae (Mammalia) from Langebaanweg, South Africa. Ann. S. Afr. Mus. Cape Town 79:213–337; 1980.

Gentry, A. W.; A. Gentry. Fossil Bovidae (Mammalia) of Olduvai Gorge, Tanzania. Parts I-II. Bull. Br. Mus. nat. Hist. (Geol.) London 29:289–446; 30:1–83; 1978.

Hendey, Q. B. The Pliocene fossil occurrences in 'E' Quarry, Langebaanweg, South Africa. Ann. S. Afr. Mus. Cape Town 69:215–247; 1976.

Hendey, Q. B. The age of the fossils from Baard's Quarry, Langebaanweg, South Africa. Ann. S. Afr. Mus. Cape Town 75:1–24; 1978.

Johanson, D. C.; M. Taieb; B. T. Gray; Y. Coppens. Geological framework of the Pliocene Hadar Formation (Afar, Ethiopia) with notes on paleontology including hominids. W. W. Bishop ed. Geological background to fossil man. London: Scottish Academic Press; 1978:549–564.

Leakey, M. D. Olduvai Gorge 3. Excavations in Beds I and II, 1960-1963. Cambridge: Cambridge University Press; 1971.

Leakey, M. D.; R. L. Hay. Pliocene footprints in the Laetolil Beds at Laetoli, northern Tanzania. Nature Lond. 278:317–323; 1979.

Lydekker, R. Crania of ruminants from the Indian Tertiaries, and supplement. Mem. geol. Surv. India Palaeont. indica Calcutta 10 (1): 88–181; 1878.

Opdyke, N. D.; E. Lindsay; G. D. Johnson; N. Johnson; R. A. K. Tahirkheli; M. A. Mirza. Magnetic polarity stratigraphy and vertebrate paleontology of the Upper Siwalik subgroup of northern Pakistan. Palaeogeogr. Palaeoclimat. Palaeoecol. Amsterdam 27:1–34; 1979.

Partridge, T. C. Reappraisal of Sterkfontein hominid site. Nature Lond. 275: 282–287; 1978.

Pickford, M. H. L. Stratigraphy and mammalian palaeontology of the late-Miocene Lukeino Formation, Kenya. Bishop, W. W. ed. Geological background to fossil man. Geol. Soc. Spec. Publ. no. 6. Edinburgh: Scottish Academic Press; 1978:263–278.

Pilbeam, D. R.; J. C. Barry; G. E. Meyer; S. M. I. Shah; M. H. L. Pickford; W. W. Bishop; H. Thomas; L. L. Jacobs. Geology and palaeontology of Neogene strata of Pakistan. Nature Lond. 270:684–689; 1977.

Pilbeam, D. R.; A. K. Behrensmeyer; J. C. Barry; S. M. I. Shah eds. Miocene sediments and faunas of Pakistan. Postilla New Haven 179:1–45; 1979.

Smart, C. L. The Lothagam 1 fauna: its phylogenetic, ecological and biogeographic significance. Coppens, Y.; F. C. Howell; G. Ll. Isaac; R. E. F. Leakey eds. Earliest man and environments in the Lake Rudolf basin. Chicago: Chicago University Press; 1976:361–369.

Taieb, M.; D. C. Johanson; Y. Coppens; J.-J. Tiercelin. Expédition internationale de l'Afar, Éthiopie (4^e et 5^e campagnes 1975–1977): chronostratigraphie des gisements à Hominidés pliocènes d'Hadar et corrélations avec les sites préhistoriques du Kada Gona. C. r. hebd. Séanc. Acad. Sci., Paris D 287:459–461; 1978.

Taieb, M.; J.-J. Tiercelin. Sédimentation pliocène et paléoenvironments de rift: exemple de la formation à Hominidés d'Hadar (Afar, Éthiopie). Bull. Soc. géol. Fr. Paris. Ser. 7; 21, 3:243–253; 1979.

Thomas, P. Recherches stratigraphiques et paléontologiques sur quelques formations d'eau douce de l'Algérie. Mém. Soc. géol. Fr. Paris. Ser. 3; 3, 2:1–51; 1884.

Vrba, E. S. The fossil Bovidae of Sterkfontein, Swartkrans and Kromdraai. Transv. Mus. Mem. Pretoria 21:1–166; 1976.

Vrba, E. S. New species of *Parmularius* Hopwood and *Damaliscus* Sclater and Thomas (Alcelaphini, Bovidae, Mammalia) from Makapansgat, and comments on faunal chronological correlation. Palaeont. afr. Johannesburg 20:137–151; 1977.

Wells, L. H.; H. B. S. Cooke. Fossil Bovidae from the Limeworks Quarry, Makapansgat, Potgietersrus. Palaeont. afr. Johannesburg 4:1–55; 1956.

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THE ARCHAEOLOGICAL INVESTIGATION OF A FORT ANCIENT COMMUNITY NEAR OHIO BRUSH CREEK, ADAMS COUNTY, OHIO

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Abstract

In 1977, the Museum Department of Archaeology totally excavated the 64,000 m^2 Killen-Grimes site on the Brush Creek-Ohio River terraces in Adams County, Ohio. The major prehistoric occupation was represented by five rectangular houses and an egalitarian burial mound assigned to a thirteenth-century-A.D. late Brush Creek Fort Ancient phase. The site, which appears associated with the adjacent Wamsley site, represents the first information on such village-related Fort Ancient activities as well as offering an alternative model of Fort Ancient cultural development.

Introduction

The Killen Ridge sites, the Wamsley Village site, and the Grimes site lay on properties which were to be affected by the construction of the Dayton Power and Light Company's Robert Killen Electric Generating Station, near Wrightsville in Adams County, Ohio (Fig. 1). While the Wamsley Village site was preserved from adverse impact, the historic Stevenson homestead and the prehistoric occupations on Killen Ridge sites and the Grimes site could not be preserved (Fig. 2). Therefore, in the spring of 1977, data recovery was implemented by the Cleveland Museum of Natural History Archaeology Department with support from the Atlanta regional office of the Interagency Archaeological Services, Department of the Interior, Heritage Conservation and Recreation Service. The excavations and analyses were under the direction of David S. Brose (Brose et al. 1979). The field crew consisted of James Brennan, Michael DeSanti, Mark Doblekar, Jan Engebretsen, Mark Holan, David Morse, Lisa Murray, Franco Ruffini, and Shaune Skinner. Lithic source identification and aspects of the lithic analyses were under the direction of Fredrick Chapman. All phases of the field and laboratory supervision for the project were performed by Donald Bier, Jr.

Fort Ancient occupations identified in the initial survey (Otto 1976) were located on the second and third alluvial terraces of the Ohio River, downstream from the mouth of Ohio Brush Creek. The earliest historical accounts of this area relate that in the late eighteenth century it was a favorite location from which belligerent aborigines would lure unwary American sojourners to their doom. Their spirit lives (Brose 1971a).

It was thought that the excavations at the Killen area would reveal evidence for a protohistoric village area between the Scioto and Miami Rivers along the Ohio (Brose 1976a). While this was not the ultimate result, perhaps a significant contribution has been made. Data concerning processes of cultural change which lead to those regional protohistoric occupations have been revealed, and the Killen-Grimes-Wamsley investigations reported (Brose et al. 1979:1–520) have shed light on a region which was as much archaeological terra incognita for the thirteenth century A.D. as it was to be historically for the seventeenth century.

Environment

The Killen site is located on the Ohio River terraces in south-central Adams County, Ohio, at the juncture of the Appalachian Plateau and the

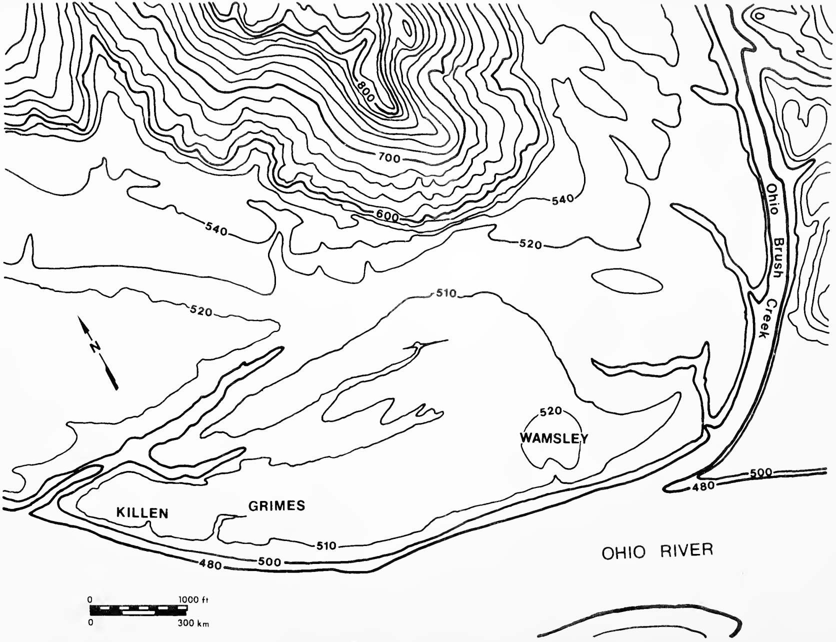


Fig. 1. Map of Killen-Grimes area near Ohio Brush Creek.

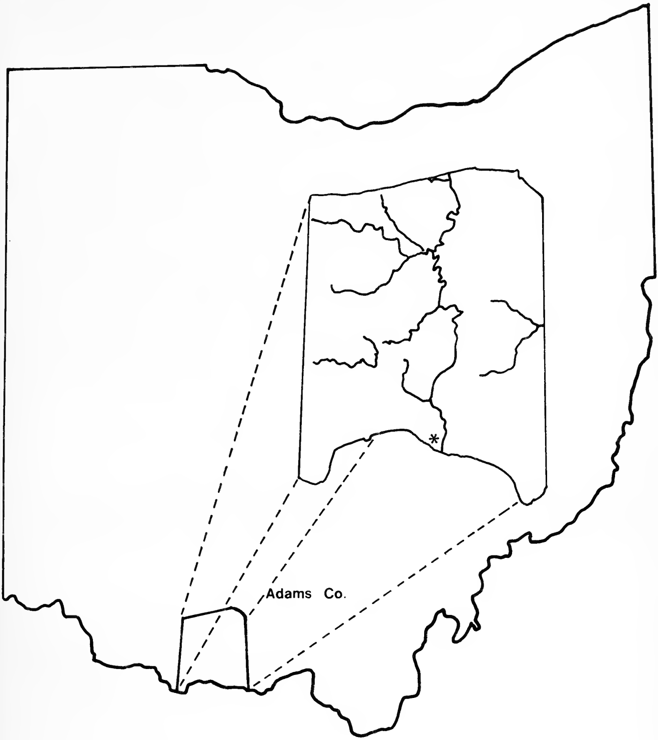


Fig. 2. Map of Adams County, Ohio.

Central Lowland Province. The northwestern portions of Adams County are glacial till plains; the eastern third of the county is a rugged portion of the unglaciated Allegheny Plateau, while the majority of the county west of Ohio Brush Creek has been termed the Lexington Plain. Ohio Brush Creek represents a tributary of the Ohio River within the eastern margins of the unglaciated plateau, most of whose drainage system lies outside of that zone (Fig. 2). These topographic differences, along with the variations in underlying bedrock and in drainage systems, created conditions of maximum diversity: there is more topographic variation within Adams County than anywhere else in the state of Ohio (see Brose et al. 1979:1–37).

In most respects, the ecological situation found at the Killen site was relatively rich for aboriginal human exploitation with a primitive technological base. The conjunction of several topographic and floral zones provided a wide variety of naturally available subsistence resources, although seasonal availability and imperfect storage technology must have created annual shortages. Riparian faunal resources would have been easily available and would have yielded significant amounts of protein for both prehistoric and historic occupants of the site. The proximity to outcrops of several varieties of chert (albeit of minimal quality) and the presence of higher quality materials in alluvial gravels would have provided a nearby source for most raw materials utilized in tool manufacture. Finally, although poorly drained, the soil associations in the vicinity of the Killen site are among the most agriculturally productive in the state, and the length of the growing season within the Ohio River valley is exceeded within Ohio only by the Lake Erie islands (Plate 1).

There is a relatively dense Fort Ancient occupation of southern Adams County centered on the floodplains of the Ohio River/Ohio Brush Creek

Plate 1. The Killen-Grimes site area looking south to the Ohio River and the Kentucky hills.

confluence. These floodplains have received closer inspection than the rugged uplands. Other than the Fox Farm site itself (Smith 1911), no Fort Ancient occupation is reported in Mason County, Kentucky, across the river, although Schwartz had reported that Fort Ancient village materials were exposed at the Mehldall Lock construction site 20 km below Maysville. The ceramics recovered from most of these sites represent a blend of Fort Ancient types characteristic of Brush Creek, Fox Farm, and Feurt components: all *could* be placed within Griffin's (1943) Madisonville focus, although typical Madisonville ceramics are absent. Griffin (1978) noted that the 1943 Madisonville focus is too gross and that "sufficient differences between sites in the western and eastern ends of the continuum along the Ohio River will eventually be recognized and these will establish a Madisonville phase on the west and a Clover phase on the east."

Essenpreis (1978) argued that differences between Clover and Madisonville sites may be structural and functional in nature within a single Madisonville phase which spans the Ohio River from at least the Muskingum to the Miami Rivers. These differing perspectives follow from the relatively differing conceptions of the cultural processes involved in the formation of the Fort Ancient culture itself (Brose 1976a; Brose et al. 1979:37–86).

Excavations, Features, and Structures

During the initial excavations of the 46 systematically located 1 x 1 m units at the Grimes and Killen tracts, it became apparent that there were few areas of continuous cultural deposits and that agriculture had truncated those deposits which did exist (see Brose et al. 1979:86–117). The only technique considered likely to yield adequate information on extant archaeological material distributions was to remove the plow-disturbed soils by mechanical stripping in order to discover subsurface features or deposits. The Grimes portion of the ridge comprised over 22,000 m^2; the Killen portion comprised over 13,000 m^2 (exclusive of the mound and previously encountered northern sheet midden). Therefore, a continuation of subsurface random sampling, while yielding some distributional data, would not yield representative samples of aboriginal features or reveal sufficient patterning for adequate reconstruction of the occupational pattern. Therefore, first on Grimes, then on Killen, transects were stripped by road grader of plow-disturbed overburden in an east-west direction. Hand-shovel skimming of these strips was followed by recording baulk profiles. Next, transects were machine stripped in a north-south direction, shovel

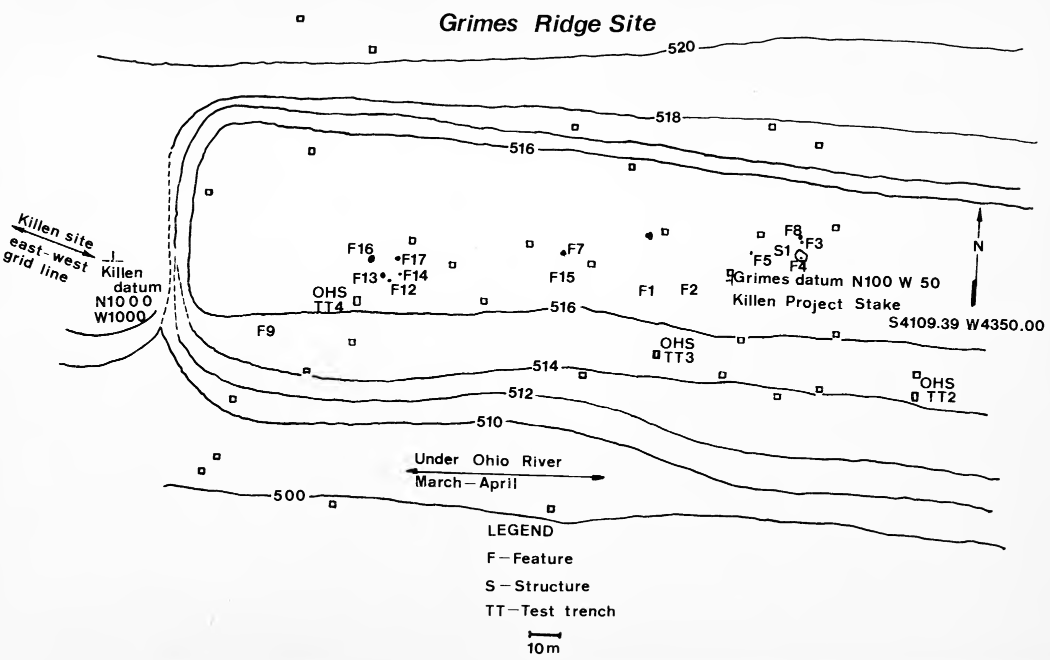


Fig. 3. Map of features and structures on Grimes tract.

skimmed, and profiles were recorded. A 20% sample of the remaining unstripped squares was tested by hand excavation, and finally the entire site area was stripped. The Grimes recovery revealed 17 aboriginal storage and/or cooking features and 1 aboriginal structure (Fig. 3). On the Killen ridge area these methods revealed a large sheet midden (Plate 2) with several burials, a burial mound, 14 aboriginal storage and cooking features, and 5 aboriginal structures (Fig. 4) (Brose et al. 1979:117–191). One feature at Grimes (Fig. 5) and two features at Killen were isolated wattle-and-daub walls, unassociated with other structural features. Several structure-free areas of intensive and localized burning occurred at both Grimes and Killen. These features had low artifact/ecofact yields, as did several small, shallow, unfired refuse pits, most of which did not yield much refuse in spite of neutral soil conditions and intensive flotation.

Several morphological subclasses of these refuse pits could be defined. Most pits were empty (Plate 3) and associated with structures, and at Killen these were located on areas proximal but external to structural walls. Such pits may be an ethnographic analog of temporary Iroquois caches of personal property.

Relatively shallow unprepared pits filled with fire-cracked rock appeared as the central feature within Grimes structure 1, which morphologi-

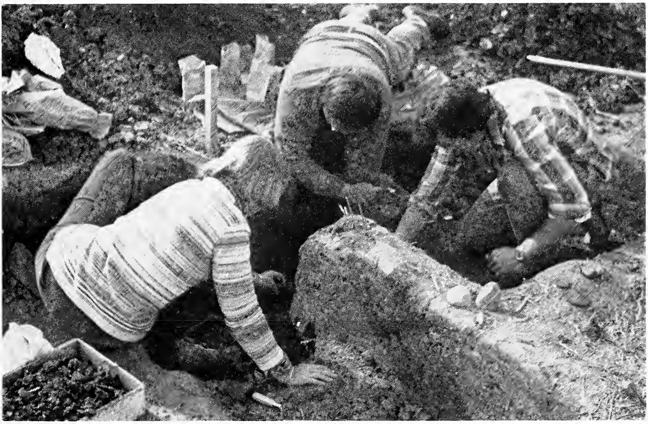


Plate 2. Archaeological recovery of flexed burial in Killen midden.

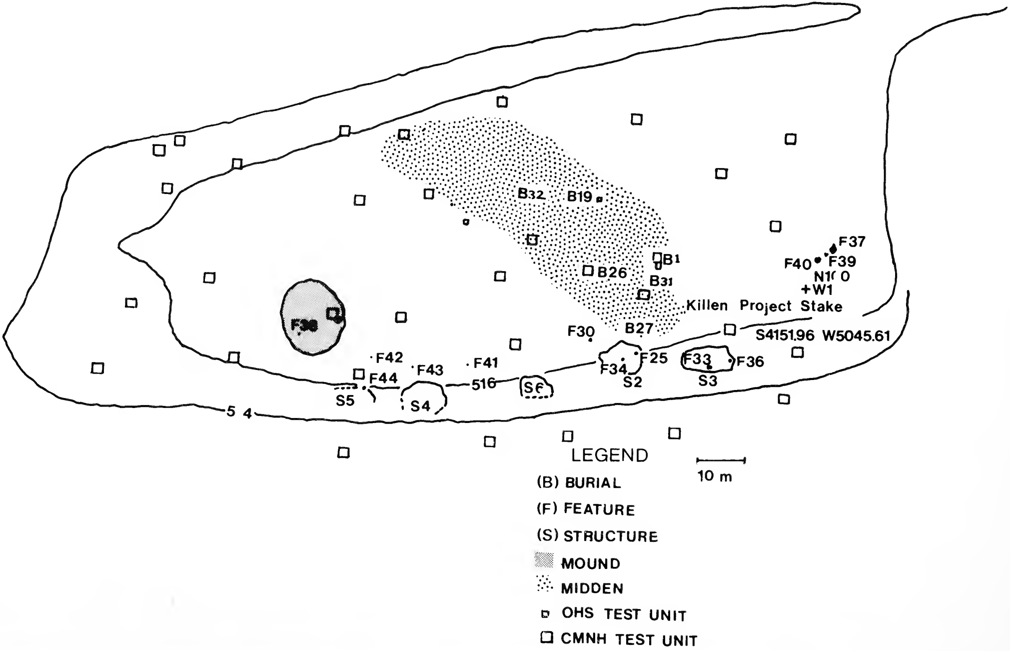


Fig. 4. Map of features and structures on Killen tract.

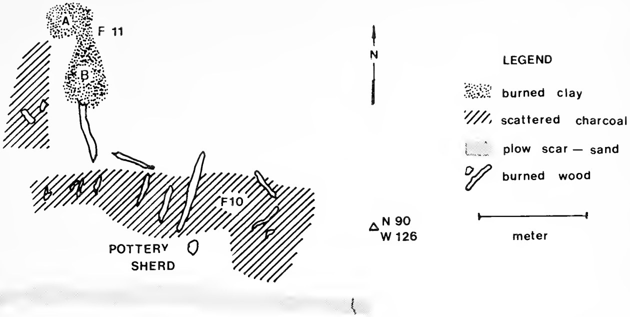


Fig. 5. Plan of Grimes features 10/11: an isolated wattle-and-daub wall burned in place.

cally and radiometrically was determined to be a Middle Woodland occupation (Brose et al. 1979:234–235, 362). Such rock-filled pits also were found as extramural features both at Grimes and at Killen. Deeper, basin-shaped, puddled-clay hearths without fire-cracked rock occurred within several of the Killen structures. These differences may reflect significant functional differences as well as the more obvious chronological differences. Unfortunately, only limited floral and faunal material could be

Plate 3. Typical empty storage pit associated with Killen structures.

recovered from these hearths (Ford 1979:514–520), and their analyses provided no resolution to this problem.

At most of the structural areas at the Killen portions of the site, fragments of burned ceramic daub were recovered, as were found at a few of the isolated walls. Typical construction methods appear to have involved setting individual posts (13 cm in diameter) vertically into the ground, to depths varying between 15 and 25 cm, at approximate 30 cm intervals (Figs. 6–9; Plate 4). A lighter horizontal framework of wattle would be woven or tied into place, and the entire structure plastered with clay, at least on the exterior. At least one such wall, that of structure 5, burned in place (Plate 5). Presumably, some waterproof roofing would have had sufficiently overhanging eaves to protect the structural walls, although no drip line was archaeologically encountered. Postholes were dug by hand, or with such ad hoc tools as clam shells or split mammal bone prior to placing the posts. Several of the larger post molds yielded such materials as well as fragments of lithic debitage and ceramics incorporated into the aboriginal backfilling of the postholes (Brose et al. 1979:139–166).

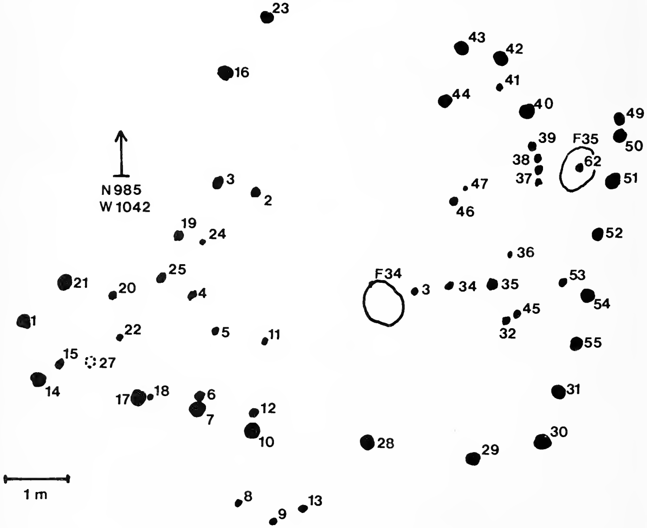


Fig. 6. Floor plan of Killen structure 2.

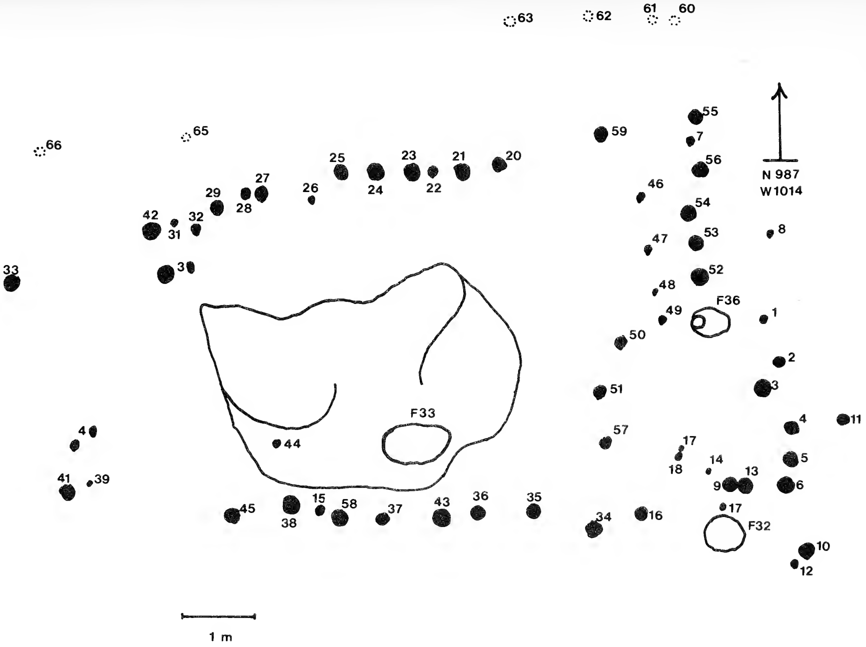


Fig. 7. Floor plan of Killen structure 3.

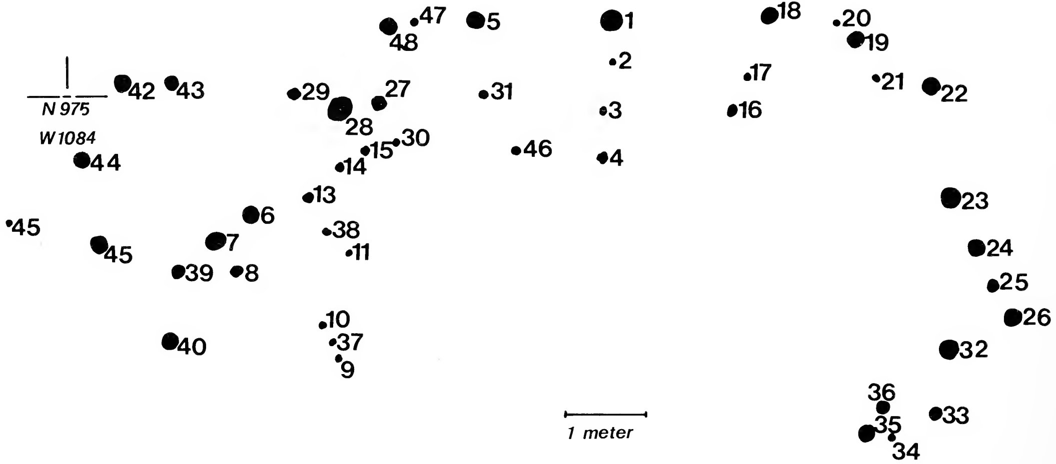


Fig. 8. Floor plan of Killen structure 4.

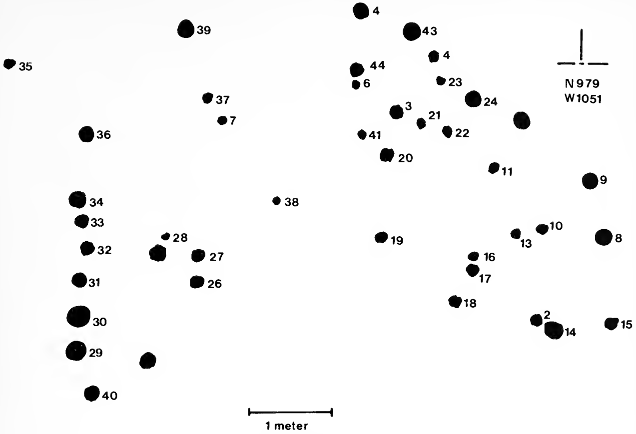


Fig. 9. Floor plan of Killen structure 6.

For at least two of the Killen structures, episodic rebuilding of walls took place. There was no evidence of post-for-post replacement, but, given the interlocking nature of wattle-and-daub construction, it may not have been much more difficult to replace an entire wall than to tear it apart to replace a single post. The life expectancy of the various structural hardwoods recovered would be less than 10 years, especially given the fact that the bases of deeper postholes were within a nearly impervious clay acting as sumps. That only two of the five Killen structures required only one wall rebuilding each suggests a limited time for family expansion or for foundation decay—no more than a single generation—if all of the structures were coeval. Indeed, the Killen structures all had similar construction. They were subrectangular with rounded corners, an off-center fire hearth, and a floor area around 52 m^2 (540 ft^2). Population estimation from floor area is culture-dependent (see Brose 1971), and there is no acceptable ethnohistoric affiliation for most of the Ohio Valley prehistoric groups (see Griffin 1978). It is nonetheless quite probable that proto–Central Algonkian groups occupied the region aboriginally, and generalized Algonkian proxemics (Brose et al. 1979:161–166) suggest between 28.0 and 35.4 ft^2 of floor space per occupant in northern areas and between 30.8 and 55 ft^2 of floor space per occupant in southern areas. The mean is 37.2 ft^2 per occupant,

Plate 4. Excavated postholes of Killen structure 3.

yielding the astounding estimate of 14.2 occupants per structure. If pits and hearth areas are removed from interior areas, the mean area for the Killen structures is 47.6 m^2, or 512 ft^2, which results in estimates of 13.7 occupants per structure. As Faulkner (1977) noted, rectangular structures (summer houses) averaged 10% to 20% greater floor areas than winter "hot" wigwams. Thus, the Killen structures may have had between 10 and 12 occupants each. Where such data exist, the short axis of all structures appears oriented WNW-ESE, perpendicular to the prevailing winds which come up the Ohio River valley. At all structures, evidence for extramural activity lies leeward.

A number of similar structures have been excavated at the coeval Incinerator site along the Miami River in Montgomery County, Ohio, where the clustering of ceramic motifs and burial areas suggests family-unit occupation (Heilman 1975, personal communication). The Blain Village site on the Scioto River in Ross County, Ohio, yielded some evidence for possible subrectanguloid, rounded-cornered, single-post houses estimated to be about 5.5 x 7.0 m, or about 450 ft^2, in area (Prufer and Shane 1970). The possible Blain structures and the Killen structures, unlike the Incinerator site structures, could all fit Mills's loose definition of Baum and Gartner "teepee rings" (Mills 1904, 1906). Other Fort Ancient structures reported from elsewhere in the Ohio Valley are more linear, larger, and later (Hanson 1966, 1975; Graybill 1980).

Killen Burial Mound

Test excavation into the central portion of the low rise on the western end of the Killen tract immediately yielded the first of 35 burials (Brose et al. 1979:167–190; Astramecki and Mensforth 1979:403–467) (Fig. 10). The extent and structure of what was thus revealed to be an artificial mound was determined by a series of 27 subsequent hand-excavated 1.5 m wide x 1 m long units, resulting in two trenches intersecting at right angles. Due to plowing of the mound's superstructure, it was not possible to determine the

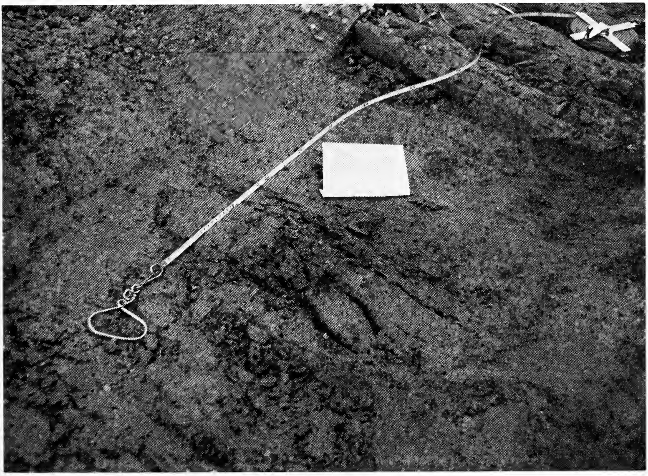


Plate 5. Burned wall section of Killen structure 5 exposed in troweling.

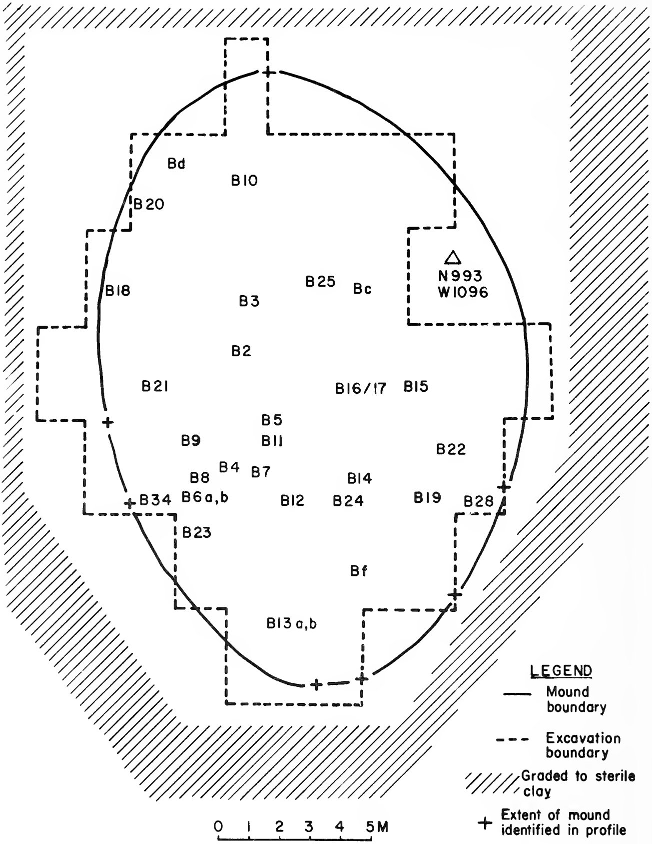


Fig. 10. Schematic plan of the Killen burial mound.

lateral extent of the mound by other means: relief approached only 27 cm. Stratigraphic profiles within the excavation units revealed that the mound construction had begun by excavation of an oval basin 16 x 12 m to 50 cm below ground surface. Within this basin, a fine sandy silt platform between 25 and 50 cm high had been placed. Burials were then placed on top of this platform or in pits which were excavated into the platform and in some cases carried down to the underlying clays (Plates 6, 7). It was possible to discern a basket-loaded structure within undisturbed sections of this platform. In several profile segments, it was also possible to discern basket-loaded structures in the subplowzone sediments which overlay some superimposed platform burials.

The remainder of the mound, excavated by hand, consisted of a plowzone, mound fill, and lensed midden deposits to the east and west margins, with the entire mound resting on the underlying clays. Several dental

Plate 6. Stratigraphic profile through edge of Killen burial mound.

Plate 7. Stratigraphic profile through central portion of Killen burial mound.

crowns were found at the transition from the plowzone to the mound fill itself, in the undisturbed furrow crests between plow scars. The fill of the mound was 25–40 cm thick at mound center, and it tapered at the edges. Of the 35 aboriginal individual interments associated with the Killen Burial Mound, nearly all of which were postpuberty, specific five- or ten-year ranges for estimated age at death were available only for 15 interments. Reliable sexual distinctions were possible only for 9 individuals. Both age and sex determinations were available only for 7 individuals.

The subsurface platform, built up in the oval depression to slightly above the original ground surface, had cut into the southwestern edge of the homogeneous Killen midden (Fig. 11). Along the northwestern margin of the mound platform, the stratigraphic profiles revealed that some sub-plowzone deposits of the midden overlay the segments of the subsurface mound platform. These data appear to conclusively demonstrate the accumulation of the midden both antedating and postdating the use of the subsurface mound platform for burial. Although no chronological sequence can be determined for those burials simply placed on the surface of

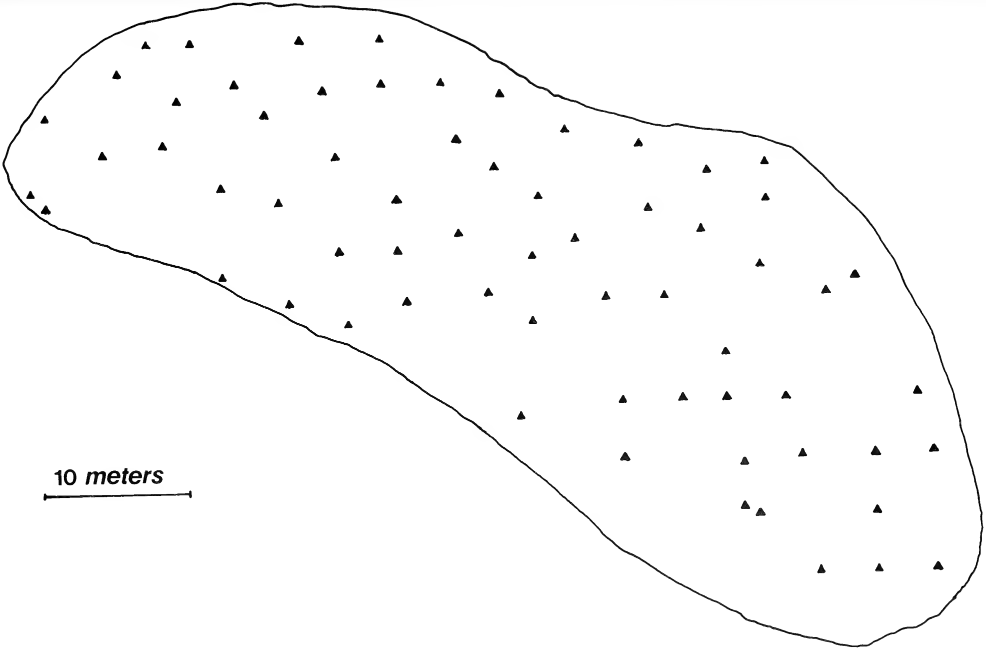


Fig. 11. Diagram of hand-excavated 1 x 0.5 m test units in Killen midden.

this platform or for those interred in isolated subplatform pits, the surface-platform Burials 6a and 6b partially overlay the subplatform pit of Burial 23, and that pit, in turn, appeared to have been cut into by the subplatform pit of Burial 9 (Plate 8).

Given the mound platform crowning and the visible mound surface, it was possible to define three zones of mound burials for the 26 in situ individuals: a clustered central group, a uniformly distributed intermediate group, and a randomly placed peripheral group. Most of the central-zone burials were placed on the platform surface, while most of the subplatform-pit burials and burials in the mound fill were located in the two more distal zones. The variables of mound zone, age, sex, orientation, posture, grave type, grave goods, and spacing show no significant intercorrelations (Brose et al. 1979:182–188). Of 3272 potential mortuary variable state combinations, the 26 in situ individuals represent 18 mutually exclusive combinations, and even these co-occurrences may be due primarily to missing data. I believe that this does not reflect any hierarchical or complex social organization. Rather, at the Killen site, whatever differential social status which may have existed in life was simply not reflected in the mortuary program. While it may be unusual, ethnographically, to discover status-differen-

Plate 8. Killen midden burial No. 9 showing degree of preservation in deep submound platform pits.

tiated societies which do not show differential burial modes, the argument that variable burial modes imply a status-differentiated society does not logically follow. It is not easy to measure the value of differing "social energy" expenses which the society itself recognized (cf. Saxe 1970). As Greber (1976) has shown, the energy-free variable of proximal vacant floor space is a major reflection of an individual's social status for some of the Hopewell groups within southern Ohio.

If any individual may be taken to represent elite status within the Killen mound, it may be Burial 14—a young male whose grave had a limestone slab and border. While all of the burials with grave goods were found on the platform surface, grave goods per se do not suggest elite status.

The most generous estimates, extrapolated to unexcavated areas, suggest that the total mound population could have only been around 40 individuals (Brose et al. 1979:185–188). If the known demography of those individuals recovered is representative, then it is safe to say that children and infants did not receive mound burial. This suggests either that ascribed status was not significant, or that such status was not ascribed to an individual until after puberty or adolescence. A large proportion of aboriginal mortality should be expected in the 0–9 and 15–19 age classes (Weiss 1973). Neither of these are represented at the Killen mound (Astramecki and Mensforth 1979:403–467). Interpolation based on missing age classes suggests that the estimated 40 mound and 6 known midden burials may have represented only 60% of the normal population mortality. This in turn implies a total expected mortuary population of approximately 67 individuals, many of which should be children. Those 30 young individuals not found at Killen yet may be found within the floors of structures at the nearby Wamsley Village site (see Brose et al. 1979:181–190).

The Killen structures themselves are seen to represent no more than an occupation of two generations' duration. Use of the mound, clearly sandwiched within the period of structure-related midden accumulation, is thus similarly limited. With the 17-year estimate for the generation, a "normalized" mortality rate of 10.5/1000/year could have produced 77 burials from a total population of 419. Such a population is far higher than what the most generous population estimates would have occupying the Killen Ridge structures alone. From recent subsurface testing and from surface collection over the past decade, the Wamsley Village appears to be similar in size and general structure to the Incinerator site excavated by Heilman (1975). That site was estimated to have had a population of 250–400 individuals. By itself, the Wamsley site would not have yielded the requisite number of adult burials found at Killen, unless higher rates of mortality were postulated (13.2/1000/year) or utilization of the Killen Burial Mound extended for more than 17.5 years. The reasonable conclusion would seem to be that Killen structures 2–6 represent an occupational locus of the Wamsley Village population (Heilman 1975).

Ceramics

The 1977 excavations at Killen-Grimes-Wamsley yielded 2105 sherds (9265.8 g). Of these, 90 were rimsherds, and 86 were decorated bodysherds or handles. In analyses of horizontal distributions, there was a separation of sherds recovered from potentially disturbed or surface contexts from ceramics recovered within their original levels of deposition. With the exception of seven Middle Woodland sherds from Grimes, the ceramics appear to represent a relatively homogeneous assemblage which can easily be categorized as Fort Ancient, although the exact placement within that category is no easy decision. The distribution of ceramics by surface finish and tempering material is presented in Table 1 for the Grimes and Killen areas.

Insofar as possible, rimsherds and bodysherds were fitted to form a minimum number of vessels for typological analysis. Similar rimsherds and bodysherds were tested against these reconstructed vessels to determine whether they could be considered to represent a separate vessel (only if two or more technological attributes differed [e.g., estimated vessel capacity, temper, surface treatment, rim profile]). This proved to be a difficult procedure; therefore, some caution must be exercised in presenting the comparative results. The pottery from Killen-Grimes (and, to a large extent, the bulk of aboriginal pottery from the Wamsley Village site as well) represents a rather undistinguished Fort Ancient ceramic assemblage. Ves-

TABLE 1
Relative Frequency of Surface/Temper Complete Sherds from Fort Ancient Contexts Only

	Killen Ridge	*Grimes*	*Total*
Shell-tempered Corded	44%	15%	59%
Shell-tempered Plain	32%	14%	46%
Grit/Mixed-tempered Corded	11%	41%	52%
Grit/Mixed-tempered Plain	13%	30%	43%
Total	100%	100%	200%

Chi Square = 49.23; d.f. = 3; $p < .001$

sel surfaces ranged from clearly cordmarked to completely plain, but sufficient ceramics showed the partial smoothing of cordmarked surfaces in most areas of the vessel (except for the basal portions) to suggest that the degree of roughened or smoothed surface was not a major concern of the aboriginal potter. Vessels displaying similar temper, rim profile, lip treatment, decorative motif and technique, and surface finish were considered to represent a single type.

Practically every ceramic vessel from this component has counterparts illustrated under a number of names. In most cases (e.g., Griffin 1943; Hanson 1966, 1975; Prufer and Shane 1970; Gartley et al. 1973, 1975; Murphy 1975; Johnson 1978), the taxonomic criteria have been loosely applied, have been rarely made explicit, and (where illustrations exist) suggest that the same ceramics can often be found under different taxa or that within a single taxon considerable difference in ceramic attribute combination is common. In attempting analysis of extant Fort Ancient ceramic typology, it became apparent that the discriminating ceramic attributes represented differing levels of taxonomic significance in Griffin's more than adequate typology (Griffin 1943). No subsequent student of Fort Ancient ceramics has had the temerity to redefine these types, being content rather to pigeonhole those new data which Griffin did not have within preexisting categories. For example, for shell-tempered ceramics, the distinct surface treatment of fabric impressing *by itself* defines the type Fox Farm Salt Pan regardless of any other ceramic attribute. The simple-stamped (or grooved paddle-stamped) surface treatment on ceramics without an added rimstrip is sufficient for assignment to the type Madisonville Grooved Paddle Stamped, while the added rimstrip is sufficient to define the type Wellsburg Simple Stamped (Mayer-Oakes 1955). Types such as Anderson Cordmarked and Incised were defined by a particular rim treatment regardless of surface treatment or temper, or of motif of rim decoration. There is considerable ambiguity as to whether this represents two types or one (Griffin 1943:344). Types such as Madisonville Cordmarked and Fox Farm Cordmarked appear to have been distinguished in 1943 solely by the shape of the strap handles, while Feurt Incised represented a modal association of attributes of tempering, surface, technique and motif of decoration, and handle shape; thus, it was never clear where Feurt Incised graded into the other types described. Had the sorting criteria for the Madisonville-Feurt-Fox Farm ceramics been consistently applied to the Baum focus sites, it is likely that the type (or types) Baum Cordmarked and Incised would be represented by five or six types at the same taxonomic level as Fox Farm Bowl (Griffin 1943:345) or Philo Punctate (Gartley et al. 1975).

Fortunately, the ceramic sample from the Killen-Grimes-Wamsley excavations is too small to justify any grandiose attempt to systematically redefine the Fort Ancient ceramic series. Yet as Griffin (1978) has stated, such reanalyses are certainly necessary if archaeologists are to use the resultant ceramic types to argue for direct Adena precursors (e.g., Rafferty 1975) or upstream invasion (e.g., Prufer and Shane 1970; Dunnell 1972). In Griffin's original studies of Fort Ancient ceramics, a variety of ceramic decoration was under analysis. Minor variations within type or variety were of little moment as the primary objective had been to compare a number of types from one site with those similar types described at other sites. The ceramic assemblage from Killen-Grimes-Wamsley is of limited size and variation, and one aim of the analysis has been to compare differences in ceramic attributes between site areas. The range of ceramic variation of this small sample of 52 minimal vessels (from about 2100 sherds) is so restricted that, with the exception of the previously noted sand-tempered ceramics from Grimes, all of the ceramics could fit within what Griffin (1943:62–63) described as Baum Cordmarked pottery from the Brush Creek component. Alternatively, these same ceramics could be assigned to such distinct types as Baum Cordmarked and Incised, Fox Farm Cordmarked, Madisonville Plain, Madisonville Cordmarked, Feurt Incised, and Baum Shell-tempered var. Blain, although in every case such type assignment must be loose, and vessels will have the disconcerting ability to slide from type to type. No strong correlations of vessel shape (Fig. 12), surface decoration, or paste existed. The few decorated ceramic fragments and handles represent so small a sample that no statistical significance can be given to the apparent association of shell tempering or to the predominance of smoothed surfaces with these attributes. The ceramics from ambiguous contexts will be ignored.

Given their variability, it might be said that the Killen-Grimes-Wamsley ceramics represent three distinct ceramic wares, as used by Griffin (1952:101, 114–116, 121), due to the differences in paste and in tempering materials. While such a distinction is warranted for the seven compact, sand-tempered, stamped sherds from Grimes, the intergradation of paste and temper, the random associations these attributes show with any and all other ceramic attributes, and the fact that even Griffin (1943) has included all of these variations within a single type strongly argue that ware distinction based on paste or temper within the bulk of the Fort Ancient pottery may be meaningless.

All of the Killen-Grimes-Wamsley ceramics seem to have been constructed of similar slightly sandy clays. Surface deposits of similar sandy clays underlie the western portions of the Killen Ridge itself and are nearly

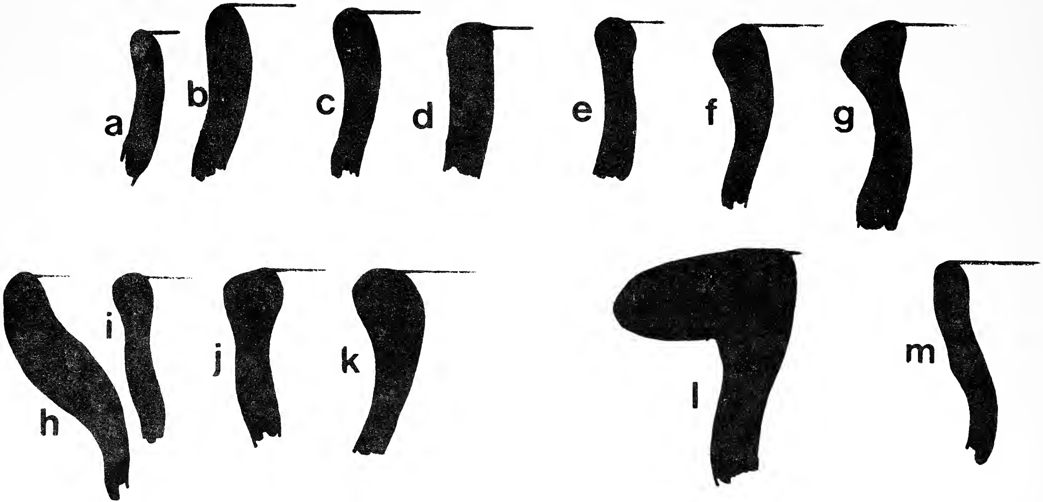


Fig. 12. Rim profiles of Fort Ancient ceramics recovered from Killen-Grimes-Wamsley excavations: exterior to left.

ubiquitous along the lowest banks of the Ohio River. Measurements for hardness were taken on a random 25% sample of all sherds larger than 2 cm in diameter. Scratch tests were made on the edges of breaks, rather than on eroded exterior and interior surfaces. All measurements indicated a Moh's hardness scale value between 2.0 and 3.5, with all but a handful between 2.0 and 2.5. Little variation within a single sherd was observed, and no correlation with temper could be demonstrated. Paste texture could be classified as grading from laminar to compact, but eroded surfaces of all sherds, save the sand-tempered "Grimes Seven," were friable. There did not appear to be any significant differences between rim and bodysherds.

Nineteen shell-tempered vessels displayed a Madisonville Cordmarked incised curvilinear guilloche (Plate 9a, c, d, o). Seven shell-tempered vessels displayed the darker paste and finer cordmarking characteristic of Fox Farm Cordmarked (Plate 9g, h), but these could equally well have been classified as more carefully executed sections of vessels, other portions of which could be considered with the plain Madisonville Cordmarked jars. However, it should be noted that that the handle and rim profiles and the overall morphology of the vessels from Killen-Grimes-Wamsley are far more Baum-like than they are Madisonville-like. Five cordmarked, mixed shell- and grit-tempered vessels from the Grimes tract (Plate 9b, e, f, n) could easily have been considered Baum Cordmarked, virturally identical to those ceramics Griffin (1943) described from the Brush Creek component. The cordmarked, grit-tempered vessels from Grimes (Plate 10c, d, m) could also be considered as the Brush Creek variant of Baum Cordmarked. Hanson (1966) wanted to refer such ceramics at the Hardin site to Mayer-Oakes's Watson Cordmarked when they occurred in a Fort Ancient site on the south bank of the Ohio River. If this approach were accepted, the north-bank equivalent should be Peters Cordmarked (see Prufer and McKenzie 1967). Further, Hanson's designation of plain grit-tempered ceramics as Scarem Plain (after Mayer-Oakes) could be followed by referring to the plain grit-tempered ceramics from Grimes as Peters Plain (after Prufer and McKenzie). Although I do not choose to do so, the mere existence of this classification option says something about Woodland / Mississippian continuities. In general, I have argued that the mixed shell- and grit-tempered ceramics from Grimes-Killen-Wamsley could be best considered to represent a Brush Creek variant of Baum Cordmarked (not all of which was) or a variant of Madisonville Cordmarked (although they lack the diagnostic handles). Most of the Killen ceramics which were plain shell-tempered or shell- and grit-tempered jars, although lacking the characteristic handles, might best be described as a Brush Creek variant of Madison-

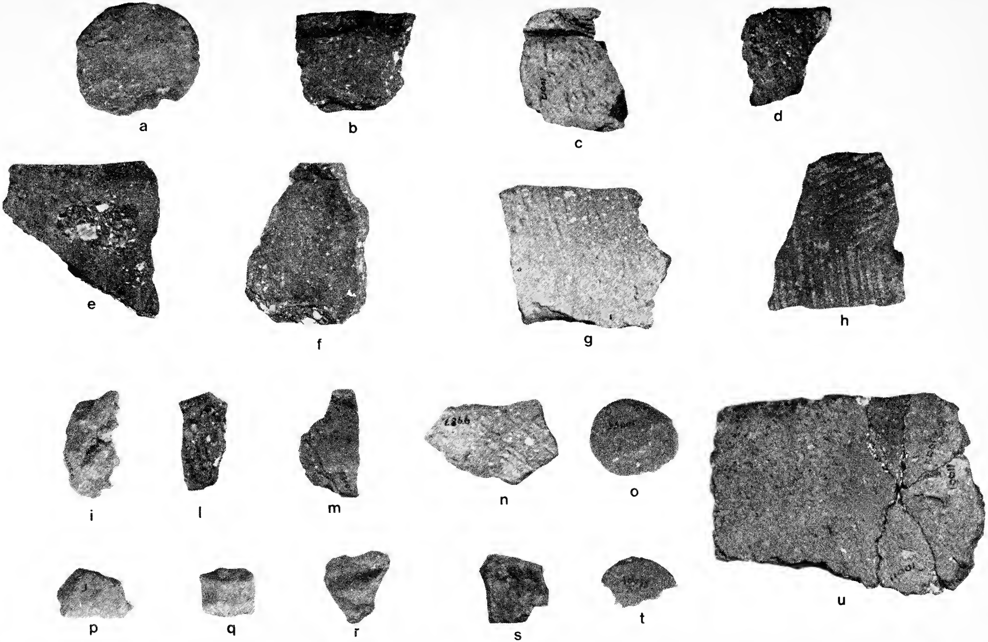


Plate 9. Various ceramics from Killen-Grimes-Wamsley; see text for descriptions.

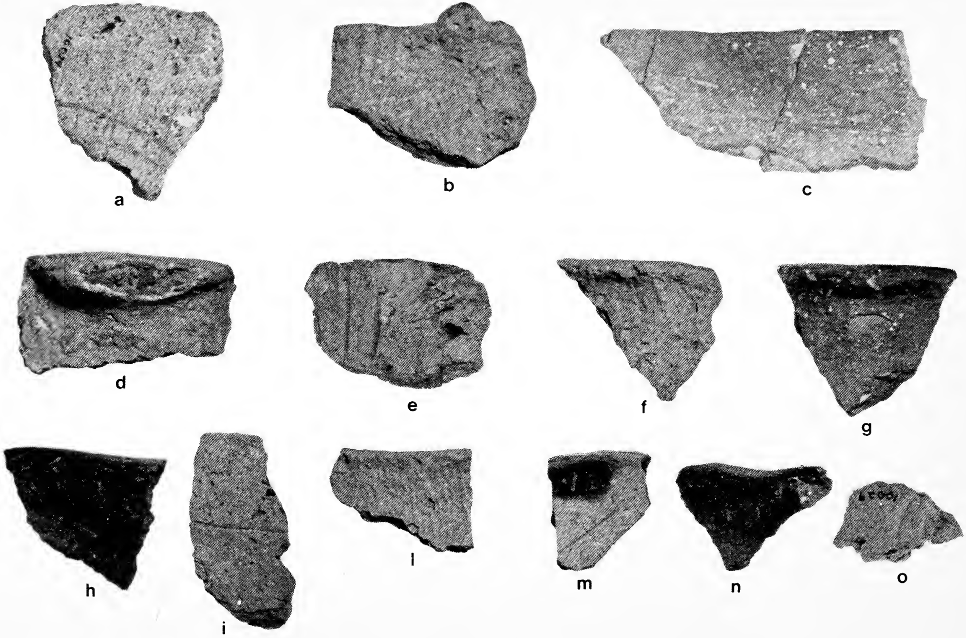


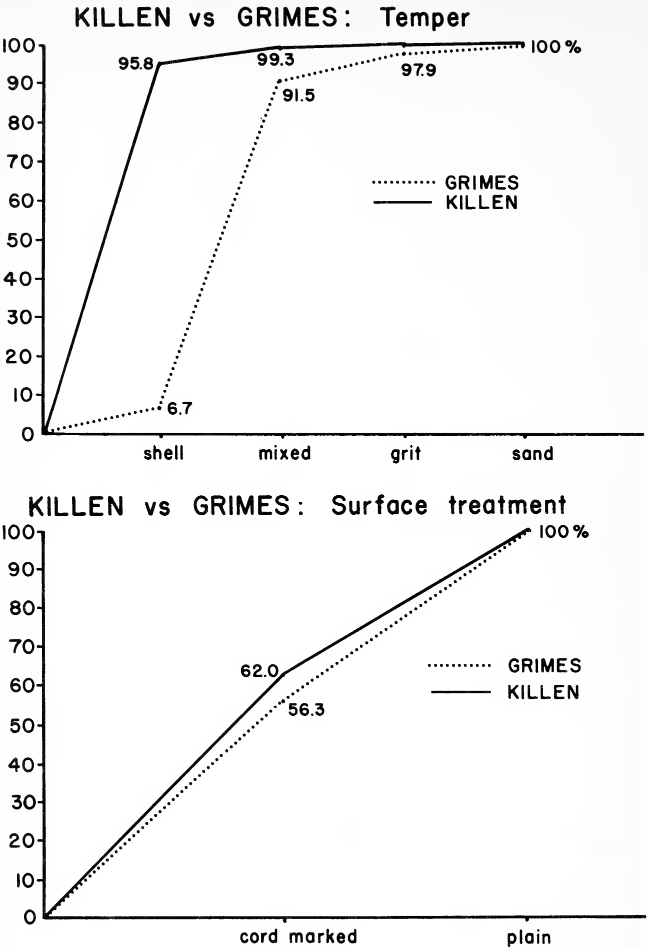
Plate 10. Various ceramics from Killen-Grimes-Wamsley; see text for descriptions.

ville Plain. Although several of the ceramic vessels from Killen-Grimes were decorated with a curvilinear guilloche, most were plain or smoothed over, without decoration. On three of the recovered vessels, the fine-line, angular incisions appear sufficient to relate them to Feurt Incised (Plate 9m, n), as they differ from Griffin's (1943) prototypic illustrations no more than do other shell-tempered, fine-line incised ceramics called Feurt at other sites (see Murphy 1975).

Several additional ceramics which occurred at the east end of the Grimes tract represent either a thin variant of Fayette Thick or a thick variant of McGraw (Plate 9l). Although not found in direct or in situ association, they were all located proximal to the seven stamped / brushed sherds (Plate 10h) from the feature at Grimes structure 1, which clearly represent Connistee types. Those ceramics were in some manner obtained from the Appalachian Summit during a Middle Woodland period which has repeatedly shown clear interaction with Ohio (Brose 1979; Keel 1977; Chapman 1973; Dickens 1976). These ceramics appear equivalent in paste to the "southeastern series" ceramics reported by Prufer (1968) from several Ohio Valley Hopewell sites (cf. Kellar 1979).

Seven complete and partial cordmarked and plain shell-tempered, edge-ground ceramic discs (Plate 10a, o, t) were also recovered: three from the Killen midden; two from the Killen structural area; and one each from the surfaces of Grimes and Killen. The only other excavated ceramic materials were 17 burned fragments of untempered clay daub (Plate 10i), most with twig and matting impressions on opposite sides. All were recovered from pits and postholes or from in situ subsurface contexts associated with the Killen structures (Brose 1979:236). In addition, unattached vessel handles with shell temper and with mixed shell and grit temper were recovered in various locations on the Killen Ridge (Plate 10p, s).

Spatial analyses of the recovered ceramics show minor but interesting areal differences (Figs. 13, 14). The Grimes tract yielded a slightly higher frequency of cordmarked surfaces and mixed- and grit-tempered paste. However, there were relatively few cordmarked and grit-tempered vessels recovered from Grimes. With the exception of the Middle Woodland structure and features, the subplowzone features at Grimes had a higher frequency of mixed-tempered and cordmarked surface vessels than did surface proveniences. This was significantly different from the ceramic attribute combinations seen on vessels recovered from similar proveniences at the Killen tract or from the Wamsley Village itself. Ceramic analyses have suggested that such minor differences in the frequency of attribute-combination variations among the ceramics recovered from var-



KILLEN vs GRIMES: Temper

KILLEN vs GRIMES: Surface treatment

Fig. 13. Cumulative frequency distributions of ceramic temper and surface treatment comparing Killen and Grimes tracts.

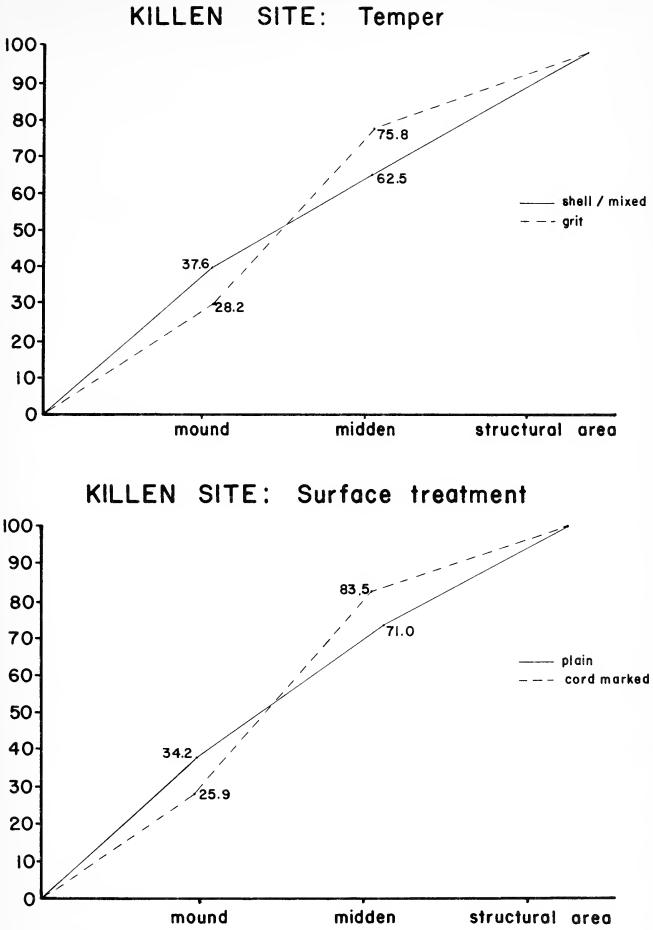


Fig. 14. Cumulative frequency distribution of ceramic temper and surface treatment from Killen mound, midden, and structural areas.

ious Killen structures may represent those slightly differing combinations of stylistic attributes which were due to the differing learning experiences of females from several social units of an extended family of sublineage nature (see Brose 1970a, 1970b, 1976b, 1979; Deetz 1964). The Killen-Grimes-Wamsley ceramic assemblage differences, although of a qualitatively greater scale, can still be considered statistically as samples from a single population (Brose et al. 1979:Tables 12–35). These differences are relatively unimportant in the archaeologist's sense of comparative regional ceramic typology; nonetheless, by virtue of the restriction to Wamsley and to the eastern end of the Grimes tract of certain ceremonially related functional types of ceramic vessel shape and surface treatment, it appeared that there were significant sociofunctional differences in the uses of ceramics between Wamsley Village and the east Grimes area and again between the Killen and the west-central Grimes areas. Salt pans (which may have had a ceremonial importance [Williams 1954, n.d.; Brown 1980]) and the more "Mississippian-shaped" open bowls are restricted to the Wamsley Village itself. Only lug-handled and small handleless vessels (primarily plain surfaced and with mixed shell/grit temper) occur at the large open burned areas located in the Grimes tract. The Killen structures yielded predominantly shell or mixed shell- and grit-tempered cordmarked and plain small bowls. These had a few narrow strap handles, and there were no lug handles recovered. The Killen midden ceramics appeared functionally similar to those from the Grimes tract, except that a wider range of vessel sizes occurred in the midden. This may reflect accumulation or redeposition from several primary disposal areas. In short, the detailed analyses of ceramics from Killen, Grimes, and Wamsley (Brose et al. 1979:228–244) suggest that to the extent that there is contemporaneity, the variability in ceramics represents not only social but also functional differences as well.

The external comparison of the Killen Ridge ceramics must, to a large degree, depend upon the validity of the established ceramic types as a nonrandom association of particular ceramic attributes themselves. As noted, there appears too little justification to uncritically continue to accept the traditional Fort Ancient ceramic typology of 1943 without revision (cf. Griffin 1978). Yet, it is still occasionally worthwhile to ignore such constraints and to proceed as if comparative ceramic typology was supportable. In such an exercise, the ceramic assemblage from Killen, characterized by a slight dominance of shell or mixed grit- and shell-tempered Madisonville/Fox Farm Cordmarked and Madisonville Plain pottery and the total absence of Anderson Cordmarked and Incised or Philo Punctate ceramic types, indicates that the Killen occupations may be placed within the Madisonville-Clover focus of the Fort Ancient aspect (Griffin 1943, 1978; Mayer-Oakes 1955) or tradition (Essenpreis 1978). The absence of types such as Wellsburg Simple-Stamped (Mayer-Oakes 1955), or of European goods, or of any strong suggestions of southeastern cultural influences, argues for a placement somewhere prior to the "protohistoric period" (viz. Hanson 1966, 1975). This relatively early Madisonville equivalence is strengthened by the low frequencies of Feurt Incised and by the presence of the Baum (or Peters) ceramics which occur at Killen. Such placement is not without its disconformities, however, as many ceramic attributes of rim profile and handle morphology at Killen Ridge differ from those of other Madisonville sites such as Fox Farm, Larken, Campbell Island, Hardin, or Buffalo (Smith 1911; Hooten and Willoughby 1922; Griffin 1943; Hanson 1966, 1975), and these ceramic attributes at Killen diverge in the direction of the rather undistinguished Baum-related ceramics from the Brush Creek component (viz. Griffin 1943), geographically the closest described Fort Ancient component.

Comparative typological analyses of the Killen Ridge ceramics thus suggest that the Fort Ancient occupation can be placed within the Madisonville focus, but certain ceramic attributes suggest that this component should be relatively early in the development in that ceramic concatenation, postdating the (unconfirmed) early Brush Creek materials equated with Baum and predating the full protohistoric development of Madisonville as seen at Madisonville itself, or at the Hardin or Buffalo Villages. On the basis of ceramics alone, the Killen Fort Ancient occupation should fall between A.D. 1100 and A.D. 1400, making them coeval with the Anderson focus of the middle Miami and Little Miami (see Brose and White 1978; Heilman 1975), or with the Feurt focus of southeastern Ohio (Murphy 1975; Gartley et al. 1973; Carskadden and Morton 1977).

Lithic Materials

Fifteen different varieties of chert or flint have been identified in the lithic assemblage recovered from the Killen site. These include three Silurian cherts, one Devonian flint, three Mississippian flints, seven Pennsylvanian flints, and one material (pebble chert) of mixed geological association. These materials and their areal frequencies are listed in Table 2. In general, although the most recent formations contain the best material for tool production (the Silurian and Devonian cherts and flints are notably poor in quality and lighter in color when compared to siliceous Mississip-

TABLE 2
Chert and Flint Raw Material Varieties Present

Formation	*Geological Period*	*Outcrops*	*Relative Frequency of Occurrence at Killen*	*Relative Frequency of Occurrence at Grimes*	*Relative Frequency of Occurrence at Wamsley*
Brassfield	Silurian	SW Ohio	11.16	11.11	18.58
Bisher	Silurian	SW Ohio	18.45	20.70	19.62
Cedarville-Guelph	Silurian	W Ohio	13.21	2.36	2.85
Delaware	Devonian	C Ohio	3.87	5.44	2.95
Indiana Hornstone	Mississippian	SC Indiana	7.86	9.93	6.26
St. Louis	Mississippian	EC Kentucky	1.48	3.55	1.96
St. Genevieve	Mississippian	EC Kentucky	.91	4.02	1.70
Upper Mercer	Pennsylvanian	EC Ohio	1.14	.95	3.00
Kanawha	Pennsylvanian	C West Virginia	.11	2.36	2.59
Zaleski	Pennsylvanian	SC Ohio	.11	2.60	1.77
Vanport Ohio Flint Ridge	Pennsylvanian	C Ohio	.00	.71	1.50
Kentucky Flint Ridge	Pennsylvanian	EC Kentucky	.34	1.65	1.77
Brush Creek	Pennsylvanian	S Ohio	1.03	.00	5.28
Pebble Cherts	Mixed	Ubiquitous	33.14	15.84	13.43
Unassignable	?	?	18.56	16.78	16.74
Totals			100%	100%	100%

pian or Pennsylvanian material), Silurian cherts predominate in the Killen site lithic assemblage. Brassfield chert outcrops are prominent along Ohio Brush Creek and several of its tributaries in the dissected uplands of Adams and Highland Counties. The exposure immediately northwest of the mouth of Ohio Brush Creek, about 350 m from the site, was extensively exploited and is well represented in the primary lithic industries at Killen. Brassfield chert is more porous in texture, tan in color (sometimes with light gray mottling), and notably more fossiliferous than is the also common Bisher. Bisher chert is locally abundant in the upper Clear Creek and Scioto Brush Creek drainages of central Highland County and northwestern Adams County and occurs as pebbles in lower Brush Creek. Despite their name and their relative quality, the Brush Creek cherts, which occur as very limited outcrops capping some of the Adams County highlands, are somewhat rare at the site. However, there are clearly considerable areal differences in the use of the Brush Creek chert at the Killen-Grimes-Wamsley occupation, and more extensive excavation at the Wamsley Village portions may alter the overall picture.

The detailed lithic analyses (Brose et al. 1979:255–360) attempted to define functional artifact types based on selective microwear studies and reconstruction of manufacturing sequences, where possible. This resulted in several overlapping technological models which involved alternative sources of raw materials; differing initial core preparation and utilization (Brose et al. 1976); differing application of heat treatment; and differing reconstructed preform, blank, and finished artifact sequences with widely differing terminal functions for final, morphologically similar artifacts (e.g., Brose 1975; Brose et al. 1976). Some attempt was made to identify, in quasi-ethnographic terms, the inferred function of these "finished artifacts" and the utilized debitage (e.g., Brose 1975, 1978a; Barber 1978). Hard-hammer and soft-hammer percussion appear at all reduction stages, although more common earlier. Pressure retouch occurs in many final reduction stages, although it may be altogether absent. Thermal alteration, never common in any Fort Ancient tradition lithic assemblage (Barber 1978; Applegarth et al. 1978), may occur at any stage or may be absent entirely. The products of this lithic strategy, whether unfinished preforms, flakes debitage, or finished formal artifacts, display variations in their indication of utilization.

Killen's lithic debitage follows a complete processual continuum, from altered nodules recognizable as cores to small secondary thinning and trimming flakes representing many of the final detrital stages in the manufacture of finished forms. As seen from the tabulations presented in Table

3, all waste categories involved in the processing of chipped-stone implements are represented, signifying that some initial reductive operations were performed at the site rather than at quarrying or collecting localities elsewhere. A probable explanation for the relative scarcity of unmodified nodules and cores is the local availability of raw material. The prolific occurrence of Brassfield chert from the nearby outcrops and the chert pebbles in the bed of Ohio Brush Creek obviated accumulation of reserve supplies.

Utilized Debitage

Utilized debitage from all areas within the Killen-Grimes-Wamsley sample occurs at a ratio of 1:4.72 with unutilized debitage, or about 21.2% of the entire lithic assemblage. Of 280 pieces utilized, 42 were utilized block cores; 89 were utilized decortication flakes; 42 were utilized pebble cores; and 126 were utilized block flakes or other primary shatter. Not one of the secondary trimming and thinning flakes was utilized. Utilization may be characterized as a condition of advance edge attrition brought about by use without preliminary alteration (Hayden 1980; Brose 1975). Although considerable variability has been observed, much utilization takes the form of minute, clustered step or hinge scars occupying a continuous expanse of the flake margin. These scars are generally steep and abrupt, terminating no more than 2 or 3 mm back from the flake edge. There is also a marked tendency for unifacial utilization in that less than 27% of the sample ($n = 76$) displayed wear on both surfaces of a single edge. In addition to this utilized debitage, 22 deliberately retouched flakes (under 8%) were recovered. Al-

TABLE 3
Relative Frequencies of Debitage Categories,
Killen-Grimes-Wamsley Occupation

Pebble Core	7.67%
Pebble Core retouched	3.82%
Block Core	4.83%
Decortication Flake	31.82%
Decortication Flake retouched	7.47%
Block Flake right angle platform	5.34%
Block Flake right angle platform retouched	2.66%
Block Flake acute angle platform	3.97%
Block Flake acute angle platform retouched	1.35%
Block Flake without platform	21.38%
Block Flake without platform retouched	6.13%

though most debitage classes are represented, retouched forms are most frequent among cores (30%) and least frequent among decortication flakes (17%). This appears quite different from coeval assemblages in northern (Brose et al. 1976; Brose 1978) or central (Shane and Prufer 1970: personal communication; Barber 1978) Ohio. Detailed analyses (Brose et al. 1979: 305–333) have revealed that the distribution of utilized debitage from the Killen-Grimes-Wamsley Village occupation is quite variable (Table 4), suggesting that tasks which required the ad hoc use of cutting and scraping edges were also variably localized.

By virture of its relative frequency in comparison to finished artifacts, the Killen utilized debitage merits attention as an important, probably indispensable, functional constituent of the Fort Ancient lithic industry. Its recognition, furthermore, has some consequence not only in the presentation of more complete descriptive data but also in the analysis of tool typology. Unfortunately, because utilized debitage is rarely discerned or adequately described in site reports, its significance outside the immediate context of the Killen site must remain largely unexplored. The only comparable data are from Barber's analysis of the 1977 Anderson Village excavations, or from the 1978 analysis of the Bluestone chipped-stone industry. In the lithic analysis of the Fort Ancient component from Bluestone (Dwyer, in Applegarth et al. 1978), utilized debitage accounted for 34% of functional lithic tools and represented just under 3% of the total debitage recovered. At Anderson Village, Barber (1978) reported that 7.56% of the

TABLE 4
Lithic Retouch or Use Modification From Killen-Grimes-Wamsley Areas as Relative Frequency of Total Assemblage of Debitage Classes

Area	*Cores (%)*	*Decortication Flakes (%)*	*Other Flakes (%)*	*Total*
Wamsley Village	5.9	3.8	7.6	17.3
Grimes burned areas	2.4	3.3	2.3	9.0
Grimes Features	6.0	3.0	12.5	19.5
Killen Structure 2	3.0	3.0	3.1	9.5
Killen Structure 3	2.5	8.5	5.2	16.2
Killen Structure 4				
Killen Features	3.0	3.0	6.8	13.8
Killen Midden	2.0	5.5	4.1	11.2
Killen Burial Mound	0.9	1.5	2.1	4.5

lithic debitage showed signs of use and that this accounted for over 52% of all functional lithic tools recovered in the unbiased samples analyzed (Barber 1978:Table 1). At the Killen-Grimes occupation, over 75% of the 370 functional lithic implements consisted of utilized debitage. However, the surface collections and the four 1 x 1 m units excavated at the Wamsley Village yielded 27 formal tools and 42 utilized debitage fragments (identified at the Ohio Historical Society by Wesley Clark 1977; and the Cleveland Museum of Natural History by F. Chapman 1978), out of only 180 lithic specimens. It is suggested that the inordinately high relative frequency of the Wamsley functional tool ratios is the direct and artificial consequence of the fact that it is a functional segment of the Killen-Grimes-Wamsley complex.

Standard Flaked Implement Forms

The 107 deliberately shaped lithic artifacts recovered from the Killen site excavations consisted of 38 triangular projectile points; 14 triangular preforms; 3 triangular blanks; 7 triangular-to-ovate "preforms"; 6 finished ovate "knife" bifaces; 6 bifacial scrapers; 1 unifacial scraper; 6 gravers and/or drills; and 9 unassignable bifacially flaked implement fragments. In addition, there were 17 whole and fragmentary Archaic-Middle Woodland projectile points (Table 5; Plate 11).

Triangular Blanks represent the initial stage in artifact preparation following the removal of cortex from chert pebbles. All blanks show evidence of hard percussive flaking with deep, short flake scars often meeting at a medial ridge on both faces. Several display cortex on one face, usually near the base, and some show multiple hinge fractures at inclusions which could not be removed by flaking.

Triangular-to-Ovate Preforms, the next reduction stage, involved a finer percussion flaking technique, primarily from the base of the blank. Larger, broader flakes were removed across both surfaces from a single edge. These preforms demonstrate a consistent edge angle during this manufacturing stage. It is at this stage that the final basal morphology is established, as are the overall maximum width and length. Many of the triangular preforms have been halted at this manufacturing stage due to inclusions which resisted further thinning. These "humps" show repeated attacks from several directions, most of which resulted in hinge or step fractures without removing the "hump."

Triangular Projectile Points appear to all fall within the Levanna or Madison types (Scully 1951; Ritchie 1961). They have been transformed

TABLE 5

Metric Attributes of Lithic Artifacts From Structural Areas, Features, and Structures at Grimes and Killen Sites
(symbols identified at end of table)

Description	*CMNH#*	*PROV*	*L*	*W*	*T*	*HL*	*HWM*	*HWN*	*BL*	*BW*	*STL*	*WT (g)*	*RM*
Madison Proj. Pt. Frag.	10397	Grimes F #15	3.23	2.20	0.79							3.52	C-G
″	10697	″	*	2.54	0.46							2.52	Bi
Chesser Proj. Pt. Frag. Notched	10353	Grimes Hearth V	*	2.05	0.59							4.19	Bi
Hafted End Scraper (Stemmed)	10353	″	3.99	3.32	1.17	1.50	2.21	2.14	2.49	3.32		14.68	Br
Chesser S-N	10379	″	3.16	1.73	0.70	0.95	1.24	1.06	2.21	1.73	2.55	3.06	KFR
Nashport Proj. Pt. Frag.	10379	″	*	3.32	0.79	1.80	2.18	1.61		3.32		10.61	OFR
Madison Proj. Pt.	9754	Killen Subzone	3.78	1.47	0.66							2.36	U
McWhinney S-N Proj. Pt.	9982	K. Clay Below PZ	4.83	2.15	0.94	1.69	1.30	1.28	3.14	2.15	3.47	8.60	OFR
Subrectangular Scraper	10393	Grimes F #15	6.42	3.67	1.65							47.01	Br
Preform	10381	Grimes F #7	3.62	2.84	1.20							10.23	OFR
Drill Frag.	10394	Grimes F #16	*	2.57	0.87							7.05	PC
Ovate Blade Frag.	10403	Grimes F #13	*	2.34	1.27							10.09	Bi
Ovate Blade Frag.	10114	Killen Struc. 3	*	2.05	0.62							2.57	Bi
Ovate Blade Frag.	10100	Killen Struc. 3	*	1.80	0.59							2.78	Bi
Subrectangular Scraper	10101	Killen Struc. 3 PM #35	2.40	2.78	0.76							5.67	PC
Drill	10088	Killen Struc. 3	4.82	2.42	0.73							6.04	U
Madison Proj. Pt. (Frag.)	10088	″	*	1.99	0.63							3.25	OFR

TABLE 5 (*continued*)

Metric Attributes of Lithic Artifacts From Structural Areas, Features, and Structures at Grimes and Killen Sites

Description	*CMNH#*	*PROV*	*L*	*W*	*T*	*HL*	*HWM*	*HWN*	*BL*	*BW*	*STL*	*WT (g)*	*RM*
Madison Proj. Pt.	10092	PM #15	2.07	1.38	0.70							1.35	U
Chesser S-N Proj. Pt. Frag. (Aff.)	10088	Killen Below Struc. 3	*	2.97	0.64			1.45	2.09	2.97	2.53	4.76	OFR
Hafted S-N End Scraper	10103	Killen Struc. 3 PM #38	1.87	2.73	0.63	1.10	2.04	1.66	0.77	2.73		3.21	KFR
Levanna Proj. Pt.	10060	Killen F #31	2.62	1.74	0.50							1.75	OFR
Madison Proj. Pt.	10060	″	4.64	1.96	0.51							3.12	Br
Long, Thick Bifacial Knife	9745	N986 W1000, PZ	6.08	1.95	1.45							15.95	PC
Madison Proj. Pt. (Frag.)	9997	N1000-40 W1017-40 Grader Cut	*	2.30	0.59							4.45	UM
″	9997	″	*	1.79	0.50							2.23	PC
″	9997	″	*	2.18	0.56							2.76	Bi
″	9997	″	*	1.78	0.58							3.37	KFR
Preform	10003	Grader Cut #1 North, PZ	4.41	2.11	0.94							8.37	PC
Blank	10005	Grader Block #2, Surface	5.00	3.00	1.63							20.93	PC
Preform	10005	″	4.70	3.66	1.75							27.41	Br
Ovate Preform	10005	″	4.27	3.35	1.64							19.93	U
Ovate Preform	10005	″	4.90	2.63	0.82							10.54	PC
Preform	10005	″	6.16	3.00	0.98							16.95	PC
Ovate Knife	10005	″	6.10	2.48	1.04							13.68	Br
Madison Proj. Pt. (Frag.)	10005	″	*	2.06	0.70							4.40	St.L.
Ovate Preform	10012	″	6.78	3.69	1.94							47.01	Br

Rectangular Scraper	10012	″	6.77	3.60	1.08							31.39	St.L.
Preform	10012	″	4.78	2.44	0.91							8.82	PC
Madison Proj. Pt.	10012	″	*	1.65	0.36							1.42	Br
Madison Proj. Pt.	10011	″	*	1.94	0.45								
Madison Proj. Pt.	10011	″	*	1.94	0.45							2.58	Bi
Madison Proj. Pt.	10011	″	3.70	1.80	0.48							2.50	OFR
Ovate Preform	10006	″	3.46	2.13	1.03							6.67	Br
Preform	10009	″	5.10	2.57	1.40							13.74	Br
Ovate Preform	10009	″	4.35	2.35	0.94							8.40	PC
Brewerton S-N Proj. Pt.	10010a	″	3.67	1.93	0.75	1.18			2.49	1.93	2.70	4.59	Br
″	10010b	″	*		0.67	1.23	2.45	1.85				3.58	Br
McWhinney H.S. Proj. Pt.	10014	″	5.23	2.82	0.97	1.24	1.21	1.16	3.99	2.82	4.28	11.88	Br
Chesser C-N Proj. Pt.	10020	″	*	3.27	0.58	1.30	1.76	1.30		3.27		5.29	U
Fragments	10010	″	*	2.60	0.62							3.29	Br
Fragments	10010	″	*	2.33	0.70							7.74	Br
Preform	9763	″	6.53	2.27	1.26							23.72	PC
Preform	9986	″	4.35	2.71	1.33							10.01	PC
Preform	9986	″	4.56	2.45	0.93							7.73	Br
Ovate Preform	9749	″	4.23	2.42	1.03							7.68	U
Scraper Bipointed	9765	″	5.19	1.74	1.26							9.93	Br
Ovate Blade	9752	″	4.18	2.79	1.25							11.77	U
Madison Proj. Pt. Frag.	9758	″		2.18	0.52							2.82	U
Madison Proj. Pt.	9986	″	3.53	1.77	0.63							3.06	U
Levanna Proj. Pt.	9987	″	3.75	2.05	0.75							3.59	PC
Blank	10370	Grimes PZ, Various Localities	6.16	4.30	2.19							56.85	Br
Preform	10372	″	3.78	2.27	0.95							8.00	PC
Preform	10397	″	3.74	2.57	2.66							11.46	PC

TABLE 5 (*continued*)

Metric Attributes of Lithic Artifacts From Structural Areas, Features, and Structures at Grimes and Killen Sites

Description	*CMNH#*	*PROV*	*L*	*W*	*T*	*HL*	*HWM*	*HWN*	*BL*	*BW*	*STL*	*WT (g)*	*RM*
Preform	10368	″	4.98	3.75	1.41							27.42	OFR
Preform	10373	″	4.61	2.76	1.90							20.82	OFR
Drill Frag.	10372	″	*	2.26	0.50							1.68	Br
Madison Proj. Pt. Frag.	10373	″	*	1.51	0.34							1.07	D
Madison Proj. Pt.	10328	″	3.08	1.93	0.45							2.05	Bi
Preform	10371	″	4.24	2.41	0.74							7.31	PC
Hafted S-N Scraper	10371	″	2.80	1.90	0.69	1.36	1.87	1.33		1.90		4.05	U
Madison Proj. Pt. Frag.	10373	″	*	1.94	0.67							2.93	Br
Levanna Proj. Pt.	10373	″	2.96	2.33	0.54							2.49	U
Blade Frag.	10372	″	*	2.85	0.81							7.72	U
Madison Proj. Pt. Frag.	10374	″	*	2.07	0.55							3.11	Bi
″	10374	″	*	2.34	0.66							3.31	Bi
Levanna Proj. Pt. Frag.	10372	″	*	2.89	0.59							2.98	OFR
Madison Proj. Pt. Frag.	10372	″	*	1.91	0.50							1.79	Z
″	10372	″	*	2.00	0.51							3.02	Bi
Hafted Scraper Stemmed	10371	″	3.64	2.90	0.77	1.55	2.43	2.25	1.21	2.90		9.06	U

Chesser S-NP	10392	″	2.83	1.42	0.58	0.85	1.42	1.15	1.98	1.41	2.17	2.21	KFR
Stemmed Proj. Pt. Frag.	10320	″	*	*	0.87	2.16	1.48	1.45				7.62	OFR
″	10316	″	*	2.70	0.80	0.78	1.30	0.83		2.70		6.77	Br
McWhinney Heavy Stemmed Proj. Pt.	10342	″	4.58	2.93	0.98	1.77	1.69	1.56	2.81	2.93	2.95	10.92	Br
McWhinney Proj. Pt. Frag.	10372	″	*	2.61	0.96	1.67	1.58	1.49		2.61		8.96	U
Brewerton E-N Proj. Pt. Frag.	10363	″	*	2.62	0.75	1.57	2.62	1.94		2.02		5.60	U
Brewerton S-N Proj. Pt. (Frag.)	10316	″	*	2.10	1.04	1.23	1.94	1.60		2.10		7.46	PC
MacCorkle (Frag.) Bifurcate Base	10360	″	*	*	*	1.17	2.34	2.24				5.15	PC
Ovate preform	10052	Mound	6.08	3.17	1.40							23.56	PC
Expanding Stem Frag.	10026	″	*	2.85	0.84	1.35	2.53	2.00		2.85		10.99	OFR
Madison Proj. Pt. Frag.	10022	″	*	2.10	0.62							3.80	Bi
″	10033	″	*	2.14	0.56							4.90	Bi
″	10019	″	*	2.08	0.46							3.34	U
Madison Proj. Pt.	10046	″	2.09	1.33	0.41							1.57	OFR
Madison Proj. Pt.	10046	″	2.45	1.46	0.22							1.30	U
Drill Frag.	10043	″	*	1.68	0.64							4.64	PC
Blank	10055	K. Mid.	7.08	4.70	2.31							68.19	Br
Preform	10055	″	5.32	2.94	1.28							16.83	PC
Drill Frag.	None	″	*	1.39	0.55	0.67	1.40					1.66	OFR
Drill Frag.	10318	″	*	1.49	0.52	1.11	1.49			0.96		1.72	U

TABLE 5 (*continued*)

Metric Attributes of Lithic Artifacts From Structural Areas, Features, and Structures at Grimes and Killen Sites

Description	*CMNH#*	*PROV*	*L*	*W*	*T*	*HL*	*HWM*	*HWN*	*BL*	*BW*	*STL*	*WT (g)*	*RM*
Madison Proj. Pt. Frag.	10318	K. Mid.	*	1.74	0.43							2.05	U
″	10318	″	*	1.44	0.70							3.03	U
Madison Proj. Pt.	10318	″	3.15	1.57	0.44							1.67	Bi
Madison Proj. Pt. Frag.	10055	″	*	1.57	0.38							1.68	Bi
Madison Proj. Pt.	10161	″	2.88	1.60	0.62							2.55	Bi
Levanna Proj. Pt.	10318	″	2.11	1.95	0.46							1.69	Br
Constricted Stem Proj. Pt. (not Archaic)	10161	″	3.87	1.70	0.77	1.28	1.15	1.06	2.57	1.70	2.88	2.66	Bi
Jack's Reef Pentagonal Proj. Pt.	10318	″	3.31	2.42	0.67							5.25	Bi

The following abbreviations have been employed:

Proj. Pt. - Projectile Point

CMNH# - Sequential Cleveland Museum of Natural History catalog number assigned to the provenience unit from which the materials were recovered. Individual artifacts carried subscript notation not reproduced in this table.

PROV - Provenance in terms of aboriginal cultural manifestation.

L - Maximum length in mm.

W - Maximum width in mm.

T - Maximum thickness in mm.

HL - Length of hafting element on point or knife or hafted scraper (see Binford 1963).

HWM - Maximum width of hafting element in mm.

HWN - Minimal width of hafting element in mm.

BL - Length of blade (cutting edge) in mm.

BW - Width of blade in mm.

STL - Length of stem in mm.

WT - Weight in grams.

RM - Raw material from which artifact was fashioned (see section on lithology for symbols.

* - Broken along measured vector.

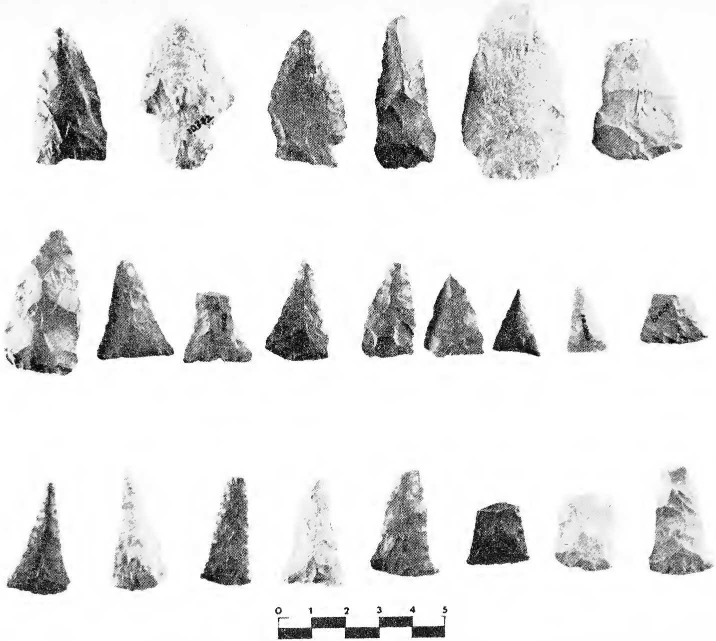


Plate 11. Chipped-stone artifacts from Killen-Grimes-Wamsley; see text for descriptions.

into finished projectile points by soft percussion flaking to thin the artifact without reduction in any other dimension, followed by the removal of a series of long shallow secondary (probably pressure) retouch flakes to create a consistent acute edge.

Triangular Bifacial Knives display scalar flake scars and small chipping scars along a single face of any edge. The degree of gloss on scar ridges and short transverse-to-oblique striations suggest use as a knife or an occasional scraping tool. These triangular bifacial "knives" differ in nearly all metric characteristics from the finished triangular projectile points described above. They do not, however, differ significantly from triangular preforms subsequently utilized as knives or scrapers (Table 6). Thus they represent an alternate pathway following the blank, which was determined *prior* to trimming to triangular preforms. Large blanks were selected for bifacial scrapers and thinned without the length or width reduction which

TABLE 6
Some Summary Statistics for Lithic Attributes (in mm) from
Fort Ancient Component of Killen-Grimes-Wamsley

Attributes	*Symbol*	*L*	*W*	*T*
Blanks	n	3.00	3.00	3.00
	x̄	60.80	46.20	20.40
	σ	10.40	15.80	3.63
	c.v.	.17	.34	.18
Preforms	n	12.00	14.00	14.00
	x̄	36.76	23.34	17.84
	σ	7.95	13.71	3.35
	c.v.	.22	.59	.19
Madison Points	n	29.00	37.00	31.00
	x̄	26.21	19.80	8.86
	σ	6.50	4.27	1.19
	c.v.	.25	.22	.13
Knives	n	6.00	6.00	6.00
	x̄	38.20	28.60	18.52
	σ	11.70	9.40	3.67
	c.v.	.31	.33	.20
Bifacial Scrapers	n	6.00	6.00	6.00
	x̄	62.78	51.97	11.43
	σ	10.99	17.28	2.33
	c.v.	.18	.33	.20

characterized those triangular preforms destined for reduction to projectile points. In contrast to sites in northern Ohio (Brose et al. 1976; Brose 1978b), among these triangular artifact classes at Killen the percentage of transverse-edge retouch shows more variation among *deliberately manufactured* bifacial scrapers than among blanks, preforms, or points *utilized* as bifacial knives or scrapers. Artifacts from every class, showing transverse retouch, were examined to determine how closely the spatial distribution of such retouch along the periphery approximated the expected distribution for discrete random occurrences along a continuous line. At Conneaut Fort, the finished projectile points display a random distribution of transverse retouch, while all other artifact classes displayed clustered-use retouch along the basal edges which exceeded the expectations of a Poisson distribution at a 95% confidence interval (Brose et al. 1976). At Killen this retouch clustered. For preforms utilized as knives or scrapers, as well as for the deliberate or predetermined bifacial knife-scrapers themselves, such transverse retouch localization in frequency alone does not distinguish between artifact classes. Previous interpretations suggested that such randomly located step and scalar fracture patterns resulted from nonscraping activities during use as a penetrating point (Brose et al. 1976). It now appears that the regularity of such retouch may be one type of the culturally determined group norm. In this light, one should review the "humpback knives" reported from the Ohio Valley and Illinois (Munson and Munson 1972; Hall 1974). While these Killen data are suggestive only, there does appear to be some distinction in lithic microstylistic traditions between the Iroquoian-related Whittlesey populations of northern Ohio (Brose 1973, 1978; Brose et al. 1976) and the Ohio River valley Fort Ancient groups in southern Ohio. Similar analyses at additional Fort Ancient sites will be needed to test this hypothesis.

Bifacial Ovates display evidence for primary use as knives, as do the bifacial triangular knives. It is hypothesized that they were manufactured from a larger nontriangular blank, possibly directly from a large secondary flake or split pebble core. The total absence of unfinished examples at Killen-Grimes suggests either that the knapping of such artifacts was carried out at Wamsley, or that few production mistakes occurred in their manufacture.

Bifacial Scrapers were "egg shaped" in general outline, and most showed localization of scraper retouch along the broader distal edge. Several displayed convergent scraper retouch along the lateral and proximal edges, and two bifacial scrapers showed discontinuous (denticulate or spokeshave) retouch along distal, proximal, and one lateral margin. This morphologically variable class could be broken into such categories as disc scrapers, denticulate scrapers, side scrapers, and convergent scrapers.

Unifacial Scrapers were made on broad expanding decortication flakes with secondary trimming on their dorsal surface only. Scraper retouch occurs along the distal edge or along the distal and lateral edges alone. Working-edge angles are more acute than those of bifacial scrapers, although such retouch tends to cover a broader portion of the flake periphery. This class displays greater morphological homogeneity than the bifacial scrapers, although this may be sampling error. The unifacial scrapers at Killen are "thumbnail" or small end scrapers in the general taxonomic terms (Brose 1973; Mayer-Oakes 1955).

Drills represent either expanded-base or T-shaped drills, and all display heavy polish and striation on the "bit" portion. The base (where present) shows small marginal fracture scars and a distinct lack of gloss on flake-scar ridges. This suggests that these drills may have been hafted rather than handheld.

Bifacial Choppers are similar to the ovate bifacial knives, although thicker and considerably larger. Both choppers were manufactured from large chert pebbles, and cortex is present on both faces. Knapping was hard-hammer percussion, with deep, short flake scars showing strong negative bulbs and radial shatter lines. Edge modification appears to have been minimal. Although polish, minute chippery, and striations exist on edges and faces, these form no clear pattern either in location or in inferred function. These implements seem to represent multipurpose, heavy-duty tools which, no doubt, fulfilled numerous industrial roles, few of which can be identified.

Miscellaneous Bifacial Fragments recovered from the excavations were too small to be unambiguous in their functional or morphological assignment. Two bladelet fragments appear to have been made on concavo-convex flakes. Basal width for these two fragments appears to have exceeded 20 mm, which is outside the range for either Hopewell or Fort Ancient bladelets from Anderson Village (White 1968; Barber 1978).

Several fragments represent bifacial blanks on the basis of size and orientation of flake scars and the freshness of the bifacially flaked edge along with an absence of secondary edge trimming. Two of these were utilized as knives or scrapers.

In addition to these analyses of the Fort Ancient lithic materials from the Killen-Grimes sites, some mention must be made of the 18 projectile points which have been (arbitrarily) assigned to non–Fort Ancient assemblages. Three "corner-removed" points were recovered from the hearth in structure 1 at Grimes, in close proximity to the aberrant ceramics of Middle Woodland affinity; 2 Late Archaic stemmed and notched points were recovered from basal clay subsoil below Fort Ancient structures; 11 Middle Archaic points were from plowzone or surface collections scattered over an area of nearly 350,000 m^2; and the only nontriangular points from in situ Fort Ancient deposits were Late Woodland, Chesser or Jacks Reef variants.

Lithic analyses confirm the existence of functional differences between the Wamsley-Grimes-Killen occupations (Table 5). Lithic debitage suggests differing functional roles for the use of areas of Killen-Grimes and Wamsley in terms of the sequences of lithic reduction activities. While structural and nonstructural areas of the Killen tract differed slightly from each other, all of them differed more significantly from the Grimes tract (Brose et al. 1979:247–350). The Grimes tract can best be characterized as an area where initial lithic reduction occurred; the Killen structural areas can best be characterized as an area of secondary knapping, or lithic reduction for final shaping; the Killen midden, while it might be characterized as an area where all phases of reduction occurred, appears primarily to represent an area where previously chipped core fragments from other zones were relocated either for disposal or for functions still unknown.

Analyses of the utilized debitage have complemented this picture. Such analyses reveal that little of the lithic debitage was actually used on the Grimes tract, although broken scrapers and drills were numerous. Within and around each of the Killen structures were areas where the lithic debitage had been intensively utilized as tools for a variety of light cutting and scraping activities: the discarded lithic material from nearly all such activities had been recovered from immediately outside the structure doorways. The Killen midden showed a lesser use of a wider variety of ad hoc heavy cutting and scraping activities, which were accomplished, for the most part, by otherwise unprepared waste flakes.

Other Lithic Artifacts

The extensive excavations of the Killen-Grimes tracts and the test excavations at Wamsley Village yielded the surprisingly low number of 23 whole and fragmentary pecked and/or ground-stone artifacts (see Plate 12). These were distributed among the following representative classes: 13 rough hammerstones; 4 celts or fragments thereof; 3 anvils; 1 "nutting-stone"; 1 teshoa or chopper; and 1 discoidal or "chunky stone." There were

Plate 12. Chipped-stone bifacial knives and selected ground-stone artifacts from Killen-Grimes-Wamsley; see text for descriptions.

no non-fire-cracked fragments recovered which could not be assigned to one or another of these categories. A metric description of these artifacts is presented in Table 7, and detailed descriptions may be found in Brose et al. (1979:336–348). One noteworthy aspect of this industrial assemblage is the total absence of the sandstone abrading stones which appear to be a common Fort Ancient characteristic (Griffin 1943).

These ground-stone tools, although everywhere infrequent, showed striking functional variability in their distribution on the Killen-Grimes tracts: "nutting-stones" were confined to the Killen midden; rough anvil stones occurred in the Killen midden and at the Killen structural area; hammerstones occurred at Killen and Grimes in nonstructural areas; and gorgets, celts, axes, adzes, and pipes did not exist on Killen-Grimes tract zones, although many have been recovered from the Wamsley Village itself (Riggs, personal communication; Otto 1976; Kelley 1976; Servey 1961; Hayes 1957). The only chunky stone recovered from excavations was from the Killen midden. These distributions all suggest that only when Killen, Grimes, and Wamsley are viewed as a single community can the artifact inventory be considered fully representative of a Fort Ancient occupation (cf. Griffin 1943).

Unfortunately, there are few detailed lithic analyses of Fort Ancient assemblages for comparative purposes. Other than Barber's (1978) analysis of a restricted sample of lithic material from Anderson Village on the Little Miami River and Dwyer's analysis of the Fort Ancient lithic assemblage from the Barker site (in Applegarth et al. 1979), *no* analyses of Fort Ancient debitage have ever been published. In the Barber and Dwyer studies, emphasis was placed upon particular aspects of the lithic analyses so that only partial comparisons may be justified, and these must be tempered by the variables particular to respective sites and to sampling differences. Still, the Anderson Village and Barker sites show no significant differences from the Killen data. For that matter, there appears to be little significant difference between *any* reported Fort Ancient lithic assemblage. Triangular knives, ovate bifacial knives, bifacial scrapers, unifacial thumbnail scrapers, and drills are common in most Late Woodland and Mississippian manifestations within the Midwest. While Hall (1974) has suggested that a low relative frequency of end scrapers was an indication of Upper Mississippian affiliation, quantified data to support such a suggestion cannot be found in the literature for Fort Ancient or for those unassigned "Upper Mississippian" components in western Ohio (see Brose et al. 1979:333–335). The low relative frequency of deliberate end scrapers at Whittlesey sites in northeast Ohio (Brose et al. 1976), a decidedly Woodland phenomenon by most crite-

TABLE 7
Ground and Pecked Stone Artifacts from Killen-Grimes, Adams Co., Ohio (in cm)

Type	*Max. Length*	*Max. Width*	*Max. Thickness*	*Material*	*Weight (grams)*
			Grimes Surface and Plowzone		
Chopper/Teshoa	18.70	7.93	2.15	Black (Cleve.) Shale	236.4
Taper-Poll Celt Fragment	5.45	4.50	2.10	Soda Granite	103.3
Taper-Poll Celt Fragment	3.55	2.00	1.20	Soda Granite	244.1
Unfinished Discoidal	3.65	3.50	1.45	Waverly Sandstone	71.0
Hammerstone	6.75	7.00	5.25	Bisher Chert	502.6
Hammerstone	6.99	6.72	4.70	Basalt	457.9
Hammerstone	7.50	5.66	2.30	Oolithic Limestone	296.0
Hammerstone	7.55	7.15	5.61	Gneiss	24.3
Hammerstone	9.29	8.89	8.35	Bisher Chert	678.7
Hammerstone	12.50	8.40	8.25	Granite	1021.6
Hammerstone	14.15	9.33	8.81	Felsite	900.3
Hammerstone	15.75	10.50	9.50	Granite	975.2
			Killen Surface, General		
Grooved Axe	8.60	5.00	2.20	Felspar Granite	296.6
Hammerstone	7.71	4.16	4.00	Granite/Gneiss	364.1
Hammerstone	9.10	9.12	8.75	Basalt	781.0
Hammerstone	11.30	7.36	5.25	Felsite	613.6
			Killen Midden Area		
Nutting-Stone/ Metate	30.21	23.47	6.95	Anorthositic Diorite	846.1
Grooved Axe	9.75	6.50	3.12	Diabase	344.1
Anvil	17.35	11.20	8.00	Waverly Sandstone	1820.2
Hammerstone	4.66	3.90	3.12	Gabbro	130.1
			Killen Structural Area Plowzone		
Anvil	19.00	16.22	8.55	Waverly Sandstone	2003.3
Anvil	16.50	12.75	6.33	Waverly Sandstone	743.7
Hammerstone	8.55	7.95	5.90	Quartzite	557.2

ria, did not further such interpretations, although the situation at Killen does not oppose it. The Killen chipped-stone materials are similar to those recovered from coeval sites in New York state, especially Early Iroquoian sites of the Oakfield phase in the Niagara Frontier region (White 1961, 1976; Schock 1976). Coeval sites in Ontario yield similar chipped-stone assemblages (Wright 1966), although complete quantified data are not available. In eastern Michigan the components of this time period (Fitting 1965, 1970) yield morphologically similar materials, although most such sites represent seriously mixed occupations. Lithic analysis of coeval single-component sites in southern Ohio, northern Kentucky, or western Pennsylvania seem to have been ignored. In light of these problems, little more can be said than that the Killen lithic assemblage is not dissimilar from numerous other late prehistoric occupations of the eastern United States which are distinguished primarily on ceramic criteria.

Organic Remains

The analyses of recovered floral and faunal remains, although limited, unambiguously indicated that the Killen-Grimes tract was a hunting/gathering resource site, occupied at all seasons during the Fort Ancient period. The analyses suggest, however, that the bulk of the subsistence economy was probably based upon a commitment to maize-beans-squash agriculture (see Ford 1979). While several large mammals appeared to have been cooked and consumed in areas immediately adjacent to the Killen structures, those fauna did not appear to have been butchered there (Storch 1979). Furthermore, these analyses strongly indicate that the remains of most of the subsistence resources which would have been required to support the Killen structure occupants were not discarded nearby. The likely explanation for this fact is that most subsistence resources were in fact not consumed at those locations.

Radiocarbon Determinations

From the Cleveland Museum of Natural History archaeological excavations at Killen-Grimes and from the limited salvage and testing undertaken at Wamsley, 10 in situ samples were submitted for age determinations. One of these samples (DIC–857A) yielded a modern reading (A.D. 1870), suggesting recent disturbance. The remaining uncorrected determinations are discussed below.

DIC #851: Charcoal in small fill lens associated with shallow pit containing Midden Burial 1 at Killen tract. Charcoal tentatively identified as *Carya* or *Jugulans*. Very small sample which yields a large standard deviation.

B.P. 750 ± 205
A.D. 1200

DIC #852: A mixed sample of hand-collected fragments and the coarse flotation fraction from feature 13 sheet midden at the Grimes tract. These fragments have been tentatively identified as representing three distinct hardwoods among which were *Acer* and *Querqus*. Feature 13 yielded charred faunal remains, fragments of pelycepod valves, and mixed shell- and grit-tempered Madisonville / Fox Farm Cordmarked ceramics.

B.P. 680 ± 70
A.D. 1270

DIC #853: Fragments of probable *Carya* saplings burned in place as three post molds from the south wall of structure 3 on the Killen tract. Very small sample with some rootlet contamination.

B.P. 710 ± 205
A.D. 1240

DIC #854: Small charcoal fragments (twigs of *Carya, Querqus*, and *Fagus*) recovered from coarse-fraction flotation from apparent hearth (feature 4), 45–52 cm level, Test Unit 2, Wamsley Village, on knoll south of mouth of Brush Creek. Associated with midden yielding abundant faunal remains, Madison Projectile points, shell-tempered Fox Farm salt pan fragments, and mixed grit- and shell-tempered Madisonville Plain ceramics.

B.P. 710 ± 105
A.D. 1240

DIC #855: Fragments of *Carya* and *Populus* saplings associated with burned daub fragments. Burned wall, feature 10, Grimes tract.

B.P. 760 ± 150
A.D. 1190

DIC #856: Charcoal fragments selected from massive shallow charcoal concentration in prepared-clay hearth, feature 34 within structure 2, Killen tract. Charcoal not identified as to species. Associated with lithic debitage and mixed shell- and grit-tempered bodysherds of Madisonville Cordmarked and Plain ceramics.

B.P. 640 ± 80
A.D. 1310

DIC #857B: Small fragments of *Querqus, Fagus*, and *Salix* charcoal from small logs on the surface of the submound clay level, 0.40 m below sand cap of mound on Killen tract. Associated with 27 semiflexed and extended human burials covered with sterile sands and midden fill containing Madisonville/Fox Farm ceramic assemblage.

B.P. 780 ± 95
A.D. 1170

DIC #861: Unidentified charcoal fragments from a fire-cracked, rock-filled pit, feature 4, within Grimes structure 1, eastern end of Grimes tract. Associated with McGraw Cordmarked and Connistee Brushed-Stamped ceramics and with corner-removed projectile points of Ohio Flint Ridge chalcedony.

B.P. 1430 ± 110
A.D. 520

DIC #862: Small fragments of *Querqus, Acer, Ulmus*, and *Carya* charcoal recovered in coarse-fraction flotation from midden level, 42–45 cm below plowzone, Test Unit 2, Wamsley Village. Associated with mixed shell- and grit-tempered horizontal lug handle, Madisonville Cordmarked rimsherd.

B.P. 620 ± 80
A.D. 1330

With the exception of sample DIC #861, which dates the Middle Woodland occupation of Grimes structure 1, the remaining acceptable eight radiocarbon determinations can all be considered to represent a single population with an average date of A.D. 1236 ± 87 (Long and Rippeteau 1974: 206–208). And while samples DIC #851 and DIC #853 have large single standard deviation values, weighting these still suggests a single acceptable range with the best estimate for the contemporaneous occupation of Killen-Grimes-Wamsley at A.D. 1236 ± 87. The date from the Middle

Woodland Grimes structure 1, feature 4, would be rejected on both statistical and archaeological grounds.

These radiometric dates as discussed are uncorrected dates based on a 5568 half-life. Correction to calendrical dates, based on the most detailed calibration available (Damon et al. 1974), suggests very little change. Corrected calendrical dates will range from A.D. 1187 to A.D. 1312 (and with the best estimate average at A.D. 1237) for the Fort Ancient occupation of the site. The Middle Woodland occupation remains unchanged at A.D. 520.

These dates are extremely close to the dates estimated on the basis of archaeological typology. They strongly confirm the interpretation of sociofunctional variation by a single population at Killen-Grimes-Wamsley.

Comparative Analyses

The general comparative aspects of the material recovered from the Killen-Grimes-Wamsley excavation can be dealt with in detail. In general terms, the Killen occupation ceramic assemblages are typologically intermediate between Griffin's (1943) Baum focus (in which he included the post-Hopewellian Brush Creek component) and his pre– or non–Clover Madisonville focus. Thus, they should date, by ceramic seriation, between A.D. 1100 and A.D. 1400. Comparative lithic analyses also suggested that the predominantly Madison projectile points from the Killen-Grimes-Wamsley occupation (Plate 11) should be typologically later than those more Levanna-like and Chesser points from Blain at A.D. 900–1100 (Prufer and Shane 1970), more or less equivalent to the major component at Anderson dated A.D. 1220 (Essenpreis 1978) and earlier than the very narrow points from the Late Anderson occupations of the Caesar Creek valley (Brose and White 1978) which were dated between A.D. 1350 and A.D. 1480. In a similar broad comparison, the Fort Ancient features and structures of the Killen-Grimes tracts should be seen as typologically intermediate between the earlier Baum focus structures reported at Gartner (Mills 1906) and Blain (Prufer and Shane 1970) and the later-protohistoric Madisonville structures from the Slone (Dunnell et al. 1971), Hardin, and Buffalo sites (Hanson 1966, 1975). It has been remarked that the closest structural analogs were to be found in the thirteenth-century Anderson focus Incinerator site (Heilman, n.d., 1975). However, unlike the structures recovered at Killen, all those previously reported Fort Ancient structures were located within concentrated (and probably palisaded) villages.

The various analyses of the five Fort Ancient structures from Killen have suggested that they were each occupied by from 10 to 12 persons and that the duration of occupation may not have extended much over a single generation. The single prepared interior hearth in each structure has suggested a single economic commensual unit. The limited stylistic variability seen in most of the lithic materials recovered from any structure suggests an extended, possibly patrilocal family, a suggestion congruent with ethnohistoric and linguistic reconstructions by Callender (1962, 1978). The best demographic and social reconstructions of the Killen mortuary population have demonstrated the rather egalitarian nature of burial ceremony and have reaffirmed the coeval interrelationships of Killen-Grimes-Wamsley.

To assemble all of these lines of evidence into a plausible reconstruction has required imputing the demographic, ceremonial, industrial, and subsistence activities missing from the Killen-Grimes tracts to the Wamsley Village. These imputations have been supported by the data recovered from the surface collection and limited test excavations of Wamsley. Still, further archaeological excavations at the Wamsley Village site may alter this reconstruction. Wamsley Village is represented archaeologically by a high density, rapid drop-off area of surface-exposed midden which is concentrated on a rather flat, 150-m-diameter knoll on the second terrace of the downstream point of the Ohio Brush Creek/Ohio River junction. The remainder of the old Wormsley property, where the Conway house stands and which runs for over 400 m to the west along this 200-m-wide terrace, has been disked, plowed, intensively surface collected, and subjected to systematically extensive subsurface excavations and trenching without yielding any Fort Ancient material. To the west of this zone lies the 250-m-long Grimes tract which has yielded discontinuous areas of burning, ephemeral sheet midden, postholes, and little else attributable to a Fort Ancient or Late Woodland occupation. Beyond this, the Killen tract runs 120 m westward to where the first and second terraces are cut by Manyouper Bayou, a seasonally filled channel. Along the Killen tract, five subrectangular structures were spaced about 10 m apart along the second terrace edge for about 80 m to where a low burial mound was built on the point where this second terrace ends. The (probably palisaded) Wamsley Village site itself is thus interpreted to have been a typical year-round Fort Ancient agricultural site wherein the majority of curatorial-industrial activities and most redistribution, processing, and consumption of subsistence resources occurred. It was the location at which the majority of the population lived and performed whatever socioceremonial rituals they performed to keep their gods in their heavens and all well with the world. Whatever activities these Fort Ancient peoples may have performed on the low upstream first terrace, below their village knoll along Ohio Brush Creek, have been lost to the 1790–1804 villages of Pleasant Bottoms/Squirrel Town; to the 1913 floods; and to the construction of the 1954 Army Corps of Engineers boat ramp. The unoccupied, gently dropping 600 m of terrace from Wamsley Village through the Grimes portions of the second terrace may represent the agricultural fields which supported the population. Ethnohistoric and historic accounts of eighteenth-century-A.D. Shawnee and Miami villages in this region report such fields with beans and squash amidst the corn stretching for miles along the river valleys (Bouquet 1765).

Toward the far end of the agricultural fields, a number of temporary structures or shades were erected for special functions during which, or in conjunction with, rather large areas of burning were associated, although no large amount of food was prepared or consumed. It is argued that some of these represent watch platforms while others were areas where family or work groups of females fired pottery without danger of burning up either village or crops, and where some males performed initial flint knapping. Beyond these activity zones were a series of five structures which appear to have been occupied at various seasons of the year by groups of mixed sexual composition. While some game was butchered and skinned in these areas and while some fish and meat may have been cooked, smoked, or stored here, most of the faunal resources were consumed back in the village. It also appears that while hides may have been initially prepared in the area of these Killen structures, it is unlikely (given the total absence of needles, awls, or beamers) that any degree of final hide preparation or actual sewing took place there. Some amount of secondary flint knapping appears to have taken place, but there is little evidence for any final tool manufacture or for much tool use near these structures. The proximity of these structures to the low burial mound surely suggests that, in addition to domestic functions, these structures could have served some segments of the village for temporary housing during periods of mortuary ritual. They may well have functioned either as lineage segment charnel houses or as postinterment purification residences, both of which are known to have been used by the local historic Indians (see Callendar 1978). On the other hand, however, the Killen houses may simply represent the extramural functional structures (viz., Watanabe 1969) which were associated with the most typical concentrated, palisaded Fort Ancient and/or Monongahela villages of the late prehistoric period in the middle and upper Ohio River drainage basin. Therein lies a problem: this reconstruction of a Fort Ancient settlement is based upon the only extensively excavated nonvillage Fort Ancient site reported in the region (Plate 13).

Plate 13. Artist's reconstruction of Fort Ancient occupation of Killen-Grimes-Wamsley.

Conclusions

It is clear from the ceramic focus or phase (Griffin 1978; Essenpreis 1978) to which the Killen Ridge component may here be attributed, just as it is clear from the available radiocarbon determinations which place the occupation firmly in the period A.D. 1150 to A.D. 1330, that in this region of the Ohio Valley, between the Miami and the Scioto Rivers, there was a gradual development of Fort Ancient ceramics, lithics, and settlement, from the styles of a more Woodland-like Baum or Brush Creek phase, to the styles of the protohistoric Madisonville/Fox Farm phase. Having examined a representative sample of the Killen-Grimes-Wamsley ceramic assemblage, Griffin stated in a letter of June 10, 1980: "While this collection of mangy sherds may not readily be placed in any one of the late 1930's Fort Ancient types, and those types not as clearly defined as they should have been, it is because this assemblage of individual fragments does not easily conform."

Agreeing that some of the Killen ceramics could be considered variants of Fox Farm Cordmarked with some decoration reminiscent of Feurt Incised, Griffin also noted that all of the vessels appeared to have been finished by paddle and anvil, and all were probably constructed by coiling. Further, he argued that the majority of vessels displayed rim attributes which normally should have precluded their being easily assigned to either Baum or Madisonville types. He concluded by expressing the hope that additional components would be located and excavated, "so that a judgment can be made whether this group fits into a projected descendent of the Brush Creek stuff at Serpent Mound" as Brose had proposed.

It should be clear that, in my opinion, such a development never looked like a ceramic assemblage characteristic of Anderson or Feurt (*sensu strictu*).

As pointed out elsewhere (Brose 1976b; Brose and White 1978; Essenpreis 1978; Griffin 1978), an earlier proposed three-area/three-phase developmental system for Ohio Fort Ancient (Prufer and Shane 1970), in light of more recent data, is at best inadequate and at worst inaccurate. The presumption that Fort Ancient appeared at a number of scattered locations within Ohio due to a single Mississippian *Drang nach Osten* still remains unsupportable without the hidden assumption of vast cultural amnesia. Furthermore, recent studies (Murphy 1975; Essenpreis 1978; Brose and White 1978; Graybill 1980) have indicated the contemporaneity of sites attributed to Madisonville and Anderson, Madisonville and Feurt, Feurt and Baum, Baum and Anderson, and Baum and Madisonville "phases." While it is true that some rather Late Woodland–like Baum (or Brush

Creek and/or Baldwin) sites antedate some protohistoric Madisonville (and/or Clover) sites, there is no justification for supposing that all Fort Ancient "phases" were not coeval to some extent in the period between A.D. 1200 and A.D. 1400. If this is correct, then the differences between these "phases" cannot be explained simply as a function of temporal change. Differential exposure to downriver Mississippian centers and to each other remains a reasonable alternative for systematic consideration.

Recently, Essenpreis (1978) has postulated the existence of a differing intersite structural hierarchy between Anderson and Madisonville Fort Ancient sites in Ohio. The Killen-Grimes-Wamsley Fort Ancient occupation could be fitted within that postulated Madisonville system as a third-order agricultural village. The models of Fort Ancient development which Essenpreis developed, and from which her hypothesis of site function was derived, differ in many respects from what I believe to have been the case (Brose 1976b). Yet along with recent discussions by Griffin (1978) and Graybill (1980), both my model and that of Essenpreis, whatever their shortcomings, seem better able to explain new data, such as Killen, than do older models predicated strictly upon invasion and imitation (e.g., Hanson 1965, 1976) or population replacement (Prufer and Shane 1970). This is appropriate, although these new data as yet do not offer evidence which would favor one or another of the more complex scenarios offered by myself, Griffin, Essenpreis, or Graybill. Nor, until such data are made available, will better syntheses be possible.

Large unexcavated portions of many major Fort Ancient villages remain. New sites, albeit of lesser importance, are still being discovered. Major museum collections remain either unanalyzed or have not been restudied in half a century. What I believe is necessary at this point is to systematically think through the problems at hand in order to discover what kinds of answers should be sought from the *existing* data to enable us to formulate models of how Fort Ancient may have developed. In that sense, indeed, further work is needed.

References

Applegarth, J. D., J. M. Adavasio, J. Donahue, D. Dirkmat, J. Dwyer, W. C. Johnson, K. Lord, B. Rovegno, and M. Vanzin

1978 46Su3 revisited. *Pennsylvania Archaeologist* 48(1):1–103.

Astramecki, Judith, and Robert Mensforth

1979 Skeletal biology. Appendix A in *Prehistoric occupation of the Killen Electric Generating Station near Wrightsville, Adams County, Ohio*, by David S. Brose. Archaeological Research Report of the Cleveland Museum of Natural History to the U.S. Department of the Interior.

Barber, Russell

1978 An analysis of the Fort Ancient lithic industry from the Anderson Village site, Warren County, Ohio. *Midcontinental Journal of Archaeology* 3:189–213.

Bouquet, Henry

1765 *An historical account of the expedition against the Ohio Indians, in the year MDCCLXIV under the command of Colo. Henry Bouquet, Esq.* Robert Clarke and Company, Cincinnati [1858 reprint edition].

Brose, David S.

1970a The archaeology of Summer Island: changing settlement systems in northern Lake Michigan. *Museum of Anthropology, University of Michigan, Anthroplogical Papers* 41.

1970b Summer Island III: an early historic site in the upper Great Lakes. *Historical Archaeology* 6:3–33.

1971a The early Indians of Ohio. *The Explorer* 12(1):20–29. Cleveland Museum of Natural History.

1971b The Southeast Ceremonial Complex in northeastern Ohio. *Ohio Archaeologist* 21(4):16–19.

1973 A preliminary report on recent excavations at the South Park site, Cuyahoga County, Ohio. *Pennsylvania Archaeologist* 43(1):25–43.

1975 Functional analysis of stone tools: a cautionary note on the role of animal fats. *American Antiquity* 40:86–93.

1976a The Whittlesey occupations of N.E. Ohio. In Late prehistory of the Lake Erie drainage basin: a symposium, edited by D. Brose, pp. 25–48. *Cleveland Museum of Natural History, Scientific Papers.*

1976b Locational analysis in the prehistory of northern Ohio. In *Paper in honor of James B. Griffin*, edited by C. Cleland, pp. 3–18. Academic Press, New York.

1978 A model of changing subsistence technology in the Late Woodland of northeastern Ohio. In Lithic technology and subsistence, edited by David Davis. *Vanderbilt University Publications in Anthropology* 20:87–116.

1979 A speculative model of the role of exchange in the prehistory of the eastern woodlands. In *Hopewell archaeology: the Chillicothe conference*, edited by David S. Brose and N'omi Greber, pp. 3–9. Kent State University Press.

Brose, David S., Donald Bier, Jr., Judith Astramecki, Fredrick Chapman, Richard Mensforth, David Morse, and Paul Storch

1979 The Fort Ancient occupation of the Killen Ridge, Adams County, Ohio. Report submitted to the U.S. Department of the Interior, H.C.R.S. Interagency Archaeological Services–Atlanta, as Part 2: Archaeological investigations of the Killen Electric Generating Station near Wrightsville, Adams County, Ohio. *Cleveland Museum of Natural History, Archaeological Research Report* 20(1):11–479.

Brose, David S., and N'omi Greber (editors)

1979 *Hopewell archaeology: the Chillicothe conference*. Kent State University Press.

Brose, David S., Gregory Wentzel, Helga Bluestone, and Patricia S. Essenpreis

1976 The Conneaut Fort site: a multicomponent Whittlesey occupation in Ashtabula Co., Ohio. *Pennsylvania Archaeologist* 46:29–77.

Brose, David S., Nancy Marie White, and Fredrick Chapman

1978 Prehistoric occupations of the Caesar Creek Reservoir: Warren, Clinton, and Green Counties, Ohio. Report to the U.S. Department of the Interior, H.C.R.S. Interagency Archaeological Services–Atlanta. *Cleveland Museum of Natural History, Archaeological Research Report* 18(1):1–148.

Callender, Charles

1962 Social organization of the central Algonkian. *Papers of the Public Museum of Milwaukee, Publications in Anthropology* 7.

1978 The Shawnee. In *Handbook of North American Indians: the Northeast*. Vol. 15 edited by B. Trigger; series editor, Wm. Sturtevant. Smithsonian Institution.

Carskadden, Jeffrey, and James Morton (editors)

1977 The Richards site and the Philo phase of the Fort Ancient tradition. *Occasional Papers in Muskingum Valley Archaeology* 1–9. Zanesville.

Chapman, Jefferson

1973 The Icehouse Bottom site, 40Mr23. *Department of Anthropology, University of Tennessee, Report of Investigations* 13.

Damon, P. E., C. W. Ferguson, A. Long, and E. I. Wallick

1974 Dendrochronology calibration of the radiocarbon time scale. *American Antiquity* 39:350–356.

Deetz, James

1965 The dynamics of stylistic change in Arikara ceramics. *Illinois Studies in Anthropology* 4. University of Illinois Press, Urbana.

Dickens, Roy

1976 *Cherokee archaeology*. University of Tennessee Press.

Dunnell, Robert

1972 The prehistory of Fishtrap, Kentucky. *Yale University Publications in Anthropology* 75.

Dunnell, Robert, Lee Hanson, Jr., and Donald Hardesty

1971 The Woodside component of the Slone site, Pike County, Ky. *Bulletin of the Southeast Archaeological Conference* 14. Morgantown.

Essenpreis, Patricia

1978 Fort Ancient settlement: an analysis of Anderson and Madisonville foci. In *Mississippian settlement patterns*, edited by Bruce D. Smith, pp. 141–168. Academic Press, New York.

Faulkner, Charles H.

1977 The winter house: an early Southeast tradition. *Midcontinental Journal of Archaeology* 2:141–159.

Fitting, James E.

1965 Late Woodland cultures of southeastern Michigan. *Museum of Anthropology, University of Michigan, Anthropological Papers* 24.

1970 *The archaeology of Michigan.* Garden City, New York.

Ford, Richard I.

1979 Ethnobotanical analysis. Appendix D, in *Prehistoric occupation of the Killen Electric Generating Station near Wrightsville, Adams County, Ohio*, by David S. Brose. Archaeological Research Report of the Cleveland Museum of Natural History to the U.S. Department of the Interior.

Gartley, Richard, Jeff Carskadden, and Tim Gregg

1973 The Philo site, a Fort Ancient component in the central Muskingum Valley. *Ohio Archaeologist* 23(4):15–19.

Gartley, Richard, Jeff Carskadden, and James Morton

1975 Ceramics from the Philo II site. *Pennsylvania Archaeologist* 46:55–76.

Graybill, Jeffrey R.

1979 A preliminary report on recent archaeological investigations in Mason County, West Virginia. *West Virginia Archaeologist* 28:2–23.

1980 *Fort Ancient occupations in the Ohio River Valley of West Virginia.* Paper Presented at the Annual Meeting of the Society for American Archaeology, Philadelphia.

Greber, N'omi.

1976 *Within Ohio Hopewell.* Unpublished Ph.D. dissertation, Department of Anthropology, Case Western Reserve University, Cleveland.

Griffin, James B.

1943 *The Fort Ancient aspect.* University of Michigan Press.

1952 Some Early and Middle Woodland pottery types in Illinois. In Hopewellian communities in Illinois, edited by Thorne Deuel. *Illinois State Museum, Scientific Papers* 5:93–129. Springfield.

1978 The Late Prehistory of the Ohio Valley. In *Handbook of North American Indians: the Northeast* 15:547–559, edited by B. Trigger (Wm. Sturtevant, series editor). Smithsonian Institution.

Hall, Robert

1974 *Humpbacks and serpents tongues.* Paper presented at the CSAS Annual Meeting.

Hanson, Lee H., Jr.

1966 The Hardin Village site. *Studies in Anthropology* 4. University of Kentucky Press, Lexington.

1975 The Buffalo site—a late 17th century Indian village (46Pu31) in Putnam County, West Virginia. *West Virginia Geological and Economic Survey, Report of Archaeological Investigations* 5. Morgantown.

Hayden, Brian

1979 *Lithic use-wear analysis.* Academic Press, New York.

Heilman, Jay

1975 *The Incinerator site: an Anderson focus Fort Ancient village in Montgomery County, Ohio.* Paper presented at the Annual Meeting of the Society for American Archaeology, Dallas.

n.d. Preliminary information on the Dayton Museum excavations at the Incinerator site, an Anderson focus Fort Ancient village. Ms. on file in Dayton Museum of Natural History.

Hooton, E., and C. Willoughby

1920 Indian Village site and cemetery near Madisonville, Ohio. *Papers of the Peabody Museum of American Archaeology and Ethnology* 3.

Keel, Bennie

1974 *Prehistory of the Appalachian Summit.* Unpublished Ph.D. dissertation, Department of Anthropology, University of North Carolina.

1975 *The Conistee phase in the Appalachian Summit.* Paper presented to the Annual Meeting of the Society for American Archaeology, Dallas.

1976 *Cherokee prehistory.* University of Tennessee Press.

Kellar, James H.

1979 The Mann site and "Hopewell" in the lower Wabash-Ohio Valley. In *Hopewell archaeology: the Chillicothe conference*, edited by David S. Brose and N'omi Greber, pp. 100–107. Kent State University Press.

Kelley, Stephen

1976 A Fort Ancient village on Ohio Brush Creek. *Ohio Archaeologist* 26(3):27–29.

Long, Austin, and Bruce Rippeteau

1974 Testing contemporaneity and averaging radiocarbon dates. *American Antiquity* 39:205–215.

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A SURVEY OF THE VERTEBRATES OF MORGAN SWAMP, ASHTABULA COUNTY, OHIO

TIMOTHY O. MATSON

Cleveland Museum of Natural History

Abstract

A two-year inventory of transient and resident vertebrate species within a large swamp in northeastern Ohio was conducted during 1979 and 1980. Twenty-four species of fish, 26 species of amphibians and reptiles, 108 species of birds, and 24 species of mammals were recorded for the area during the time interval.

Introduction

Relatively few of the many bogs and swamps formerly distributed throughout northeastern Ohio remain unaltered. Most have been modified by draining or lumbering and then converted to pasture or other agricultural uses. One such wetland, Morgan Swamp, has experienced partial drainage, and its forests have dwindled through repeated cutting. Today this swamp persists as only a remnant of its original area (Hicks, 1933). Despite repeated man-caused perturbations and reductions in size it exhibits high plant species diversity and provides habitats and environmental conditions suitable for numerous species of threatened or endangered vascular plants and vertebrate animals.

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Description of Study Area

Morgan Swamp is located at 41° 38′ 45″ north latitude and 80° 53′ 45″ west longitude in west-central Ashtabula County (Fig. 1), the northeasternmost county in Ohio. Portions of the study area are found in four townships; Morgan, Trumbull, Rome, and Hartsgrove. The area consists of nearly 688 hectares of which approximately 405 hectares are marshland and forest; the remaining 283 hectares consists of old fields and agricultural lands.

Morgan Swamp lies to the west of the Grand River in the Grand River Valley at an elevation of about 247 meters above sea level. Soils of the area consist mostly of lacustrine deposits of clay and silt. The heavy soils and low relief of less than 6 meters create conditions conducive to the formation and maintenance of wetlands. Hicks (1933) provides a discussion of the soils, flora, and a brief history of the area up to the early 1930s.

A gravel road divides the area approximately into northern and southern halves. The area to the north consists of old fields and agricultural croplands, active gas wells, and residences along the western and northern perimeters with large expanses of wetlands, beaver ponds, and youthful secondary swamp forests exhibiting low plant species diversity. The area to the south is composed of youthful secondary swamp forests with low plant species diversity, few beaver ponds, a swamp forest approaching maturity with high plant species diversity, fields, and dwellings along the western and southern borders. The Grand River forms the eastern boundary for the entire study area. Portions of the area were logged within the last 15 years (Kumpulainen, personal communication), which accounts in part for the low species diversity on the north side of the road. An additional feature which merits description consists of debris from a demolished building located in the east central section of the study area. The remnants are localized in an old field and were found to provide refuge for several species of snakes which were not encountered elsewhere.

Within the swamplands and forests are myriad beaver ponds and meadows with lush stands of plants, such as, *Sphagnum sp., Calla palustris, Nuphar advena, Anchistea virginica, Osmunda cinnamonea, Cephalanthus occidentalis, Viburnum recognitum,* and *Nyssa sylvatica.* The secondary forests are characterized by *Viburnum recognitum, Lindera benzoin, Populus grandidentata, Acer rubrum, Ulmus americana, Fraxinus americana*; numerous wildflowers, such as *Trillium grandiflorum, Trillium erectum, Hepatica acutiloba, Geranium maculatum*; and numerous species of *Viola.* On

FIG. 1. QUADRANGLE LOCATION

drier sites *Quercus borealis, Quercus alba, Liriodendron tulipifera, Trillium undulatum,* and *Dalibarda repens* grow.

An isolated stand of *Tsuga canadensis* forest persists, creating a restricted habitat characteristic of plant communities farther north. Otherwise hemlocks are confined to growing on the shallow ravine slopes or as scattered, isolated individuals throughout the secondary forest. The present *Tsuga* forest represents only a small remnant of the hemlock forest that originally covered about 40% of the 5 square mile area known as Morgan Swamp (Hicks, 1933).

Drainage for the study area is poor because of a flat topography and clay soils. Crooked Creek with its various branches provides drainage south to the Grand River for the western portion of the area. Several smaller unnamed streams course east or southeast and enter the Grand River directly. One small unnamed stream flows north and joins Trumbull Creek outside of the study area. All the drainage is to the Grand River and thus to Lake Erie (United States Geological Survey, 1970. East Trumbull Quadrangle, Ohio).

The bottom substrate of all ponds and small streams examined, except those of portions of Crooked Creek, consists of silts, clays, and detritis of varying depth. In deeper, slow-flowing portions of Crooked Creek the channel bottom materials also consist of silts and clays; however, rocks and gravels cover the bottom of stretches exhibiting swifter flow and frequently form riffles. Depths of the beaver ponds vary to approximately 2.5 meters but average between 0.6 meter and 1 meter. Crooked Creek varies in depth from several centimeters over riffles to more than 2 meters in the deepest pool.

Methods

Field work began in the early spring of 1979 and extended through the autumn of 1980. The fish species were sampled during the spring, summer, and fall of 1980 by using a dip-net (0.5 centimeter mesh) and a 4.6 meter seine 0.5 centimeter mesh. In addition, several species of fish were netted in 1979 while sampling for larval amphibians. Notes on the species captured and their relative abundance at the site were recorded. Specimens collected in the field were placed in 10% formalin and taken to the laboratory for sorting and identification.

Adult amphibians and reptiles were uncovered by overturning logs, boards, and other debris found on the soil and by actively searching each habitat repeatedly in different seasons and under varying weather conditions. The adults were captured by hand or dip-net, whereas amphibian larva were sampled by dip-netting or seining. Evening visits to the study area were made in the spring and early summer to search for amphibians at potential breeding sites.

Observations of avian species either observed visually or heard calling or singing during each visit to the study area were noted along with the number of individuals of each species. In order to obtain as complete a list as possible of the species of birds residing in or transient through the study area in such a brief period of time, considerable effort was directed to examining the diverse habitats for various species of birds, especially during the spring migratory period. Although a nesting survey was not conducted, those species observed to be nesting in the area were noted but are not reported here.

The species of mammals found in the study area were determined primarily by trapping and visual observation. Several types of mammal traps were employed to sample species of small mammals. In the late summer and early fall of 1979, Sherman live traps (7.62 x 8.89 x 22.86 cm), Victor mouse and rat traps, and pitfalls (3 pound coffee cans) were used. In the summer of 1980 conibear kill traps were also utilized to add another dimension to the inventory. The trapping survey was designed to be incluse of all observer-defined habitats. Traps were baited with either oatmeal or a mixture of oatmeal, peanut butter, and bacon grease, or sardines or chicken entrails. The traps were positioned at intervals of approximately 15 meters with one trap per station and were set for three consecutive nights. During the two years the trapping survey was conducted, a total of 2413 trap nights were accumulated.

A brief questionnaire concerning the abundance of several species of small mammals and reptiles was prepared and presented to residents of the immediate area and to local trappers and collectors who frequent the area. In most cases the data gathered by these methods were not used to determine presence or absence of a species but were used to supplement field data gathered during the period of study.

All specimens collected during the course of the study were deposited in the vertebrate collections of the Cleveland Museum of Natural History.

Results

During the period of this study 24 species of fishes, 26 species of amphibians and reptiles, 108 species of birds, and 24 species of mammals were recorded for the study area. An annotated list of the vertebrate species is presented in Table 1. It should be noted that the classification concerning relative abundance is a subjective judgment on the part of the primary investigator, and that the terms used are somewhat arbitrary. A particular classification would not necessarily indicate equal numbers of individuals when applied to different species. Certain designations of relative abundance, such as "rare," may be better listed as undetermined when based on only one or very few observations of the species, since the time and techniques employed in searching and sampling may not have been adequate to fully determine the relative abundance of the species. Nevertheless, the species presented in Table 1 provide baseline data for the study area and should be viewed in that respect. Undoubtedly in years to come additional species will be added to the species list for each vertebrate group, especially to the list of avian species.

TABLE 1
Annotated list of vertebrate species observed at Morgan Swamp, Ashtabula County, Ohio, during 1979 and 1980

(FISH)	
Umbra limi	Abundant in vegetation in many beaver ponds; occurs in some natural permanent ponds
Esox americanus vermiculatus	Common in beaver ponds, less common in slow-flowing parts of Crooked Creek
Catostomus commersoni commersoni	Common in deeper beaver ponds, less common in Crooked Creek
Hypentelium nigricans	Common in flowing portions of Crooked Creek
Campostoma anomalum anomalum	Common in Crooked Creek
Ericymba buccata	Uncommon, found only in Crooked Creek
Notemigonus chrysoleucas	Common to abundant in beaver ponds and deeper parts of Crooked Creek; one of the most frequently encountered species
Pimephales notatus	Common in beaver ponds and Crooked Creek
Pimephales promelas	Common in beaver ponds and Crooked Creek
Rhinichthyes atratulus meleagris	Uncommon to common in swift-flowing parts of Crooked Creek
Semotilus atromaculatus atromaculatus	Common in most parts of Crooked Creek
Ictalurus melas	Common in deeper slow water of Crooked Creek, present in beaver ponds
Ictalurus natalis	Uncommom
Culaea inconstans	Common in dense stands of aquatic vegetation in beaver ponds
Ambloplites rupestris rupestris	Uncommon, found only in Crooked Creek

Lepomis cyanellus	Uncommon in beaver ponds, more frequent in Crooked Creek
Lepomis gibosus	Common in beaver ponds and Crooked Creek
Lepomis macrochirus	Common in beaver ponds and Crooked Creek
Micropterus salmoides salmoides	Only one capture, in Crooked Creek
Etheostoma caeruleum	Common in riffles of Crooked Creek
Etheostoma flabellare flabellare	Common in riffles of Crooked Creek
Etheostoma nigrum nigrum	Uncommon, found in slow-moving water of Crooked Creek
Percina maculata	Only one capture, in swiftly flowing section of Crooked Creek
(AMPHIBIANS)	
Ambystoma maculatum	Common in young secondary swamp forest; egg masses in natural permanent ponds
Notophthalmus viridescens virescens	Uncommon, young secondary swamp forest, mature secondary swamp forest, ditch along Shaffer Road
Hemidactylium scutatum	Uncommon, young secondary swamp forest, edge of beaver ponds or natural permanent ponds
Plethodon cinereus cinereus	Uncommon to common in young secondary swamp forest, most common in mature secondary swamp forest
Plethodon glutinosus glutinosus	Rare, only one individual uncovered
Bufo americanus americanus	Common in young secondary swamp forest, mature secondary swamp forest, and beaver ponds and natural ponds in breeding season
Hyla crucifer crucifer	Abundant in young secondary swamp forest, mature secondary swamp forest, beaver ponds, and natural ponds
Hyla versicolor versicolor	Common in young secondary swamp forest, mature secondary swamp forest, beaver ponds, and natural ponds

TABLE 1 (*continued*)
Annotated list of vertebrate species observed at Morgan Swamp, Ashtabula County, Ohio, during 1979 and 1980

Rana catesbeiana	Common around swamp, larger beaver ponds, and natural permanent ponds; uncommon along Crooked Creek
Rana clamitans melanota	Abundant in swamp, beaver ponds, and natural ponds; in young secondary swamp forest; and swamp area in secondary mature swamp forest
Rana pipiens pipiens	Uncommon to common along ditches and in old fields
Rana sylvatica	Uncommon in young secondary swamp forest (mostly confined to ravines with intermittent streams); common throughout mature secondary swamp forest
(REPTILES)	
**Eumeces fasciatus*	Rare, in dry upland area of young secondary swamp forest; one individual observed
Diadophis punctatus edwardsi	Common; all individuals found under demolished building
****Coluber constrictor constrictor*	Common; under demolished building, old fields
Elaphe obsoleta obsoleta	Common; young secondary swamp forest, mature secondary swamp forest
Lampropeltis triangulum triangulum	Common; all individuals observed under demolished building
Nerodia sipedon sipedon	Common to abundant; demolished building, swamp, beaver ponds, natural ponds, Crooked Creek
**Storeria dekayi dekayi*	Common
**Storeria occipitomaculata occipitomaculata*	Common
Thamnophis sauritus sauritus	Common in swamp, borders of beaver ponds and natural ponds,

	Crooked Creek, young secondary swamp forest, mature secondary swamp forest
Thamnophis sirtalis sirtalis	Common in swamp, demolished building, borders of beaver ponds and natural ponds, Crooked Creek, young secondary swamp forest, old field, and mature secondary swamp forest
**Sistrurus catenatus catenatus*	See discussion
Chelydra serpetina serpetina	Common; swamp, beaver ponds
Clemmys guttata	Rare, only one individual found; see discussion
Chrysemys picta marginata	Common; beaver ponds, swamp
(BIRDS)	
Ardea herodias herodias	Common; swamp, beaver ponds
Botarus lentiginosus	Uncommon; swamp, beaver ponds
Branta canadensis canadensis	Common; swamp, beaver ponds, agricultural fields
Anas platyrhynchos platyrhynchos	Common; swamp, beaver ponds
Anas discors	Common; swamp, beaver ponds, natural permanent ponds
Aix sponsa	Common; swamp, beaver ponds, natural permanent ponds
***Lophodytes cucullatus*	Rare; one (1) nesting record
Cathartes aura septentrionalis	Common; overhead flights
Accipiter cooperii	Uncommon
Buteo jamaicensis borealis	Common; overhead flights
Buteo lineatus lineatus	Common; overhead flights
Buteo platypterus platypterus	Uncommon; overhead flights
Falco sparverius sparverius	Common; old field, along roadsides
Bonasa umbellus monticola	Common to abundant in young secondary swamp forest; less common in mature secondary swamp forest
Charadrius vociferus vociferus	Uncommon; agricultural fields
Philohela minor	Uncommon to common; edge of beaver ponds, swamp, young secondary swamp forest
Zenaida macroura carolinensis	Common; old field, along roads

TABLE 1 (*continued*)
Annotated list of vertebrate species observed at Morgan Swamp, Ashtabula County, Ohio, during 1979 and 1980

Columba liva	Uncommon; vicinity of human dwellings
Coccyzus erythrophthalmus	Common; young secondary swamp forest, forested pond edges
Bubo virginianus virginianus	Common; young secondary swamp forest, mature secondary swamp forest
Strix varia varia	Common; young secondary swamp forest, mature swamp forest
Chordeiles minor	Common; flights over swamp, beaver ponds
Chaetura pelagica	Rare; only one observation
Archilochus colubris	Common; young secondary swamp forest, mature secondary swamp forest, swamp, pond edges
Megacerle alcyon alcyon	Common; beaver ponds, swamp
Colaptes auratus luteus	Common; young secondary swamp forest, mature secondary swamp forest
Dryocopus pileatus	Rare to uncommon; holes evident, only one observation
Melanerpes carolinus zebra	Common; young secondary swamp forest, mature secondary swamp forest, standing dead trees in swamp and beaver ponds
Melanerpes erythrocephalus	Common; mature secondary swamp forest, young secondary swamp forest, standing dead trees in swamp and beaver ponds
**Sphyrapicus varius varius*	Rare; one observation of two birds
Picoides villosus villosus	Common, mature secondary swamp forest, young secondary swamp forest, standing trees in swamp, and beaver ponds
Picoides pubescens medianus	Common; mature secondary swamp forest, young secondary swamp

	forest, standing trees in swamp, and beaver ponds
Tyrannus tyrannus	Common; old field, swamp, beaver ponds, along roads
Myiarchus crinitus boreus	Very common; mature secondary swamp forest, young secondary swamp forest, forests along pond edges
Sayornis phoebe	Common; young secondary swamp forest, beaver ponds
Empidonax virescens	Common; mature secondary swamp forest, young secondary swamp forest
Empidonax minimus	Uncommon; young secondary swamp forest, mature secondary swamp forest
Contopus virens	Common; mature secondary swamp forest
Nuttallornis borealis	Rare; one individual observed
Eremophila alpestris	Common; agricultural fields
Iridoprocne bicolor	Common; swamp, young secondary swamp forest, beaver ponds
Stelgidopteryx rufficolis serripennis	Rare; one individual observed
Hirundo rustica erythrogaster	Common; old field, swamp, beaver ponds, around dwellings
Pronge subis subis	Common; swamp, beaver ponds
Cyanocitta cristata bromia	Very common; young secondary swamp forest, mature secondary swamp forest, beaver ponds
Corvus brachyrhynchos brachyrhynchos	Common; old field, in flight over all areas
Parus atricapillus	Common; young secondary swamp forest, mature secondary swamp forest, borders of swamp, beaver ponds
Parus bicolor	Common; young secondary swamp forest, mature secondary swamp forest, borders of swamp, beaver ponds

TABLE 1 (*continued*)
Annotated list of vertebrate species observed at Morgan Swamp, Ashtabula County, Ohio, during 1979 and 1980

Sitta carolinensis cookei	Common; young secondary swamp forest, mature secondary swamp forest
Troglodytes aedon	Common; young secondary swamp forest, borders of swamp, beaver ponds
Dumetella carolinensis	Common; young secondary swamp forest, borders of swamp, beaver ponds
Toxostoma rufum rufum	Uncommon; borders of young secondary swamp forest, beaver ponds, swamp
Turdus migratorius migratorius	Common; young secondary swamp forest, mature secondary swamp forest
Hylocichla mustelina	Common; young secondary swamp forest, mature secondary swamp forest
Catharus guttatus faxoni	Common; young secondary swamp forest, mature secondary swamp forest, borders of swamp
Catharus ustulatus swainsoni	Common; young secondary swamp forest, mature secondary swamp forest
Catharus fuscescens fuscescens	Common; young secondary swamp forest, mature secondary swamp forest
Sialia sialis sialis	Common; old field, along roads, beaver ponds, young secondary swamp forest, (in migration)
Polioptila caerulea caerulea	Common; young secondary swamp forest, mature secondary swamp forest
Regulus calendula calendula	Common; young secondary swamp forest, mature secondary swamp

	forest, borders of swamp and beaver ponds
Bombycilla cedrorum	Common; young secondary swamp forest, beaver ponds, swamp
Sturnus vulgaris	Common; along roads, human dwellings
Vireo griseus	Rare; one individual observed
Vireo flavifrons	Uncommon; young secondary swamp forest, beaver ponds, swamp
Vireo olivaceus	Very common; young secondary swamp forest, mature secondary swamp forest, beaver ponds
Vireo philadelphicus	Rare; one individual observed
Vireo gilvus gilvus	Uncommon; mature secondary swamp forest, young secondary swamp forest
Vermivora lawrencei	Rare; one individual observed
Vermivora pinus	Very common; young secondary swamp forest, borders of swamp, beaver ponds
Vermivora peregrina	Common; young secondary swamp forest, mature secondary swamp forest
Vermivora ruficapilla ruficapilla	Common; young secondary swamp forest, mature secondary swamp forest
Dendroica petechia aestiva	Very common; young secondary swamp forest, borders of swamp, beaver ponds
Dendroica magnolia	Common; young secondary swamp forest, borders of swamp, beaver ponds
Dendroica tigrina	Uncommon; young secondary swamp forest
Dendroica coronata coronata	Abundant in migration; young secondary swamp forest, mature secondary swamp forest, borders of swamp, beaver ponds
Dendroica virens virens	Common; young secondary swamp

TABLE 1 (*continued*)
Annotated list of vertebrate species observed at Morgan Swamp, Ashtabula County, Ohio, during 1979 and 1980

	forest, mature secondary swamp forest
Dendroica cerulea	Uncommon; mature secondary swamp forest
Dendroica fusca	Common; mature secondary swamp forest, young secondary swamp forest
Dendroica pensylvanica	Common; young secondary swamp forest
Dendroica castanea	Common; young secondary swamp forest, mature secondary swamp forest
Seiurus aurocapillus	Common; mature secondary swamp forest, young secondary swamp forest
Geothlypis trichas	Very common; young secondary swamp forest, swamp borders of beaver ponds
Icteria virens	Rare; one individual observed
Wilsonia pusilla pusilla	Rare; one individual observed
Wilsonia canadensis	Uncommon; young secondary swamp forest
Passer domesticus	Absent from all areas except roads and near human dwellings
Dolichonyx oryzivorus	Common; old field
Sturnella magna magna	Common; old field, along roads
Agelaius phoeniceus phoeniceus	Common; swamp, beaver ponds, old field
Icterus spurius	Rare; one individual observed
Icterus galbula	Very common; young secondary swamp forest, mature secondary swamp forest, swamp
Quiscalus quiscula versicolor	Common; young secondary swamp forest, beaver ponds, swamp
Molothrus ater ater	Common; swamp, beaver ponds,

	young secondary swamp forest, mature secondary swamp forest, old field
Piranga olivacea	Common; young secondary swamp forest, mature secondary swamp forest
Cardinalis cardinalis cardinalis	Common; young secondary swamp forest, mature secondary swamp forest, borders of beaver ponds, swamp
Pheucticus ludovicianus	Very common; young secondary swamp forest, mature secondary swamp forest
Passerina cyanea	Common; young secondary swamp forest, mature secondary swamp forest
Carpodacus purpureus purpureus	Rare; one individual observed
Carduelis tristis tristis	Very common; young secondary swamp forest, old field
Pipilo erythrophthalmus	Common; young secondary swamp forest, field-forest ecotone
Passerculus sandwichensis savanna	Uncommon; old field, farm lands
Junco hyemalis hyemalis	Common; old field, young secondary swamp forest, mature secondary swamp forest, beaver ponds
Spizella pusilla pusilla	Common; old field, farm lands
Zonotrichia leucophrys leucophrys	Rare; one individual observed
Zonotrichia albicollis	Uncommon to common; young secondary swamp forest
Melospiza georgiana georgiana	Very common; swamp, beaver ponds
Melospiza melodia	Very common; young secondary swamp forest, swamp, beaver ponds, old field, farm lands
(MAMMALS)	
Didelphis marsupialis virginiana	Common; young secondary swamp

TABLE 1 (*continued*)
Annotated list of vertebrate species observed at Morgan Swamp, Ashtabula County, Ohio, during 1979 and 1980

	forest, mature secondary swamp forest, old field, farm lands
Sorex cinereus ohioensis	Common; mature secondary swamp forest, young secondary swamp forest
Blarina brevicauda kirtlandi	Very common to abundant; old field, mature secondary swamp forest, swamp, beaver ponds, young secondary swamp forest
Condylura cristata cristata	Common; young secondary swamp forest, mature secondary swamp forest
Procyon lotor lotor	Common; old field, mature secondary swamp forest, young secondary swamp forest, swamp, beaver ponds
**Mustela vison mink*	Common; swamp, young secondary swamp forest
Mustela erminea cicognanii	Rare; one individual captured
**Mephitis mephitis nigra*	Uncommon; old field, mature secondary swamp forest, young secondary swamp forest
**Vulpes fulva fulva*	More common than *Urocyon*
**Urocyon cinereoargenteus cinereoargenteus*	Less common than *Vulpes*
Marmota monax rufescens	Common; old field, young secondary swamp forest, mature secondary swamp forest
Tamias striatus refescens	Common; young secondary swamp forest, mature secondary swamp forest
Tamiasciurus hudsonicus loquax	Common; young secondary swamp forest, mature secondary swamp forest
Sciurus niger rufiventer	Common; young secondary swamp forest, mature secondary swamp forest

Glaucomys volans volans	Rare; one individual observed
Castor canadensis canadensis	Common; beaver ponds, swamp, young secondary swamp forest
Peromyscus leucopus noveboracensis	Abundant; young secondary swamp forest, mature secondary swamp forest, swamp, old field
Microtus pennsylvanicus pennsylvanicus	Common; old field, swamp, beaver ponds
Ondatra zibethicus zibethicus	Common; swamp, beaver ponds
Mus musculus	Rare in wild, common around dwellings
**Rattus norvegicus*	Common around dwellings; no captures
Zapus hudsonius americanus	Common; young secondary swamp forest, old field fence row
Sylvilagus floridana mearnsii	Uncommon; old field, young secondary swamp forest
Odocoileus virginianus borealis	Common; young secondary swamp forest, mature secondary swamp forest, old field

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*Based only upon questionnaire data or personal communication.

**No individuals were observed during the 1979–1980 study. However, a nesting record consisting of one egg found in 1967 exists in the ornithology collection of the Ohio State University (Trautman, 1980, personal communication).

***Although no intergrades (*Coluber c. constrictor* x *C. c. foxi*) were observed during the study, intergrades have been captured within the study area (Strong, personal communication).

Discussion

Several of the vertebrate species listed in Table 1 are of particular importance at this point in time to the fauna of Ohio because of their status within the state. The following vertebrate species are listed by the Ohio Biological Survey (OBS) or the Ohio Division of Wildlife (ODW) as either being threatened (T) or endangered (E) with extinction within the state: *Hemidactylium scutatum* (E, OBS, ODW), *Clemmys guttata* (E, OBS, ODW), and *Sistrurus catenatus* (T, OBS). Four *Hemidactylium scutatum* were found in the youthful secondary swamp forest, usually near beaver ponds or other permanent ponds under bark of saturated logs not necessarily associated with *Sphagnum* or other mosses. One specimen was uncovered under a large log near the top of a ravine on a comparatively dry site.

Only one *Clemmys guttata* was observed in the field. The specimen was discovered dead and in a state of decay. However, based upon the results of a questionnaire submitted to several residents and trappers in the area (Froncek, 1980), the species may be more common than the field observations indicate.

The presence of *Sistrurus catenatus* cannot be explicitly determined from this survey. During the two years that field data were gathered, no *Sistrurus* individuals were encountered. On several occasions specific locations were searched extensively and unsuccessfully for the species. However, corroborating data from the questionnaire indicate that the species apparently does inhabit the Morgan Swamp (Froncek, 1980; Oehlenschlager, 1980; Strong, 1980; Kumpulainen, 1980; personal communications).

In August 1980 a single specimen of *Mustela erminea* was captured in the swamp-forest ecotone. The status of this species in Ohio is currently undetermined. In recent years several specimens have been taken in nearby areas of Ashtabula County and adjacent Lake County (Case, 1980; Welch, 1980; personal communications). This species, based on the data available for Morgan Swamp, probably should be listed as rare.

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References

American Fisheries Society. List of common and scientific names of fishes from the United States and Canada. Special Publication No. 6, 3rd edition; 1970.

American Ornithologists' Union. Checklist of North American birds, 5th edition; 1957.

American Ornithologists' Union. Thirty-second supplement to the American Ornithologists' Union checklist of North American birds. The Auk, **90**: 411–419; 1973.

American Ornithologists' Union. Thirty-third supplement to the American Ornithologists' Union checklist of North American birds. The Auk, **93**: 875–879; 1976.

Bishop, Sherman C. Handbook of salamanders. Ithaca, NY: Comstock Publishing Co.; 1943.

Bissell, James K. Previously unpublished list of vascular plants of Morgan Swamp, Ashtabula County, Ohio; 1980.

Bole, B.P., Jr., and P.N. Moulthrop. The Ohio recent mammal collection in the Cleveland Museum of Natural History. Sci. Pub. Cleve. Mus. Nat. Hist. **5**(6):83–181; 1942.

Brayton, Aaron M. Report on the mammals of Ohio. Irvington, IN: n.p.; 1878.

Burt, William H. Mammals of the Great Lakes region. Ann Arbor, MI: The University of Michigan Press; 1957.

Collins, J.T., J.E. Huheey, J.L. Knight, and H.M. Smith. Standard common and current scientific names for North American amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Herpetological Circular No. 7; 1978.

Conant, Roger. The reptiles of Ohio. Notre Dame, IN: University of Notre Dame Press; 1951.

Eddy, Samuel. The freshwater fishes. Dubuque, IA: Wm. C. Brown Co.; 1969.

Hall, E.R. *Mustela cicognanii*, the short-tailed weasel, incorrectly ascribed to Ohio. Amer. Midl. Nat. **18**:304; 1937.

Hall, E.R., and K.R. Kelson. The mammals of North America. New York: The Ronald Press Co.; 1959.

Henninger, W.F. Two mammals new for Ohio. Jour. of Mammalogy **2**:239; 1921.

Hicks, Lawrence E. The original forest vegetation and the vascular flora of Northeastern Ohio–Ashtabula County. Ph.D. thesis, Ohio State Univ.; 1933.

Hicks, Lawrence E. The breeding birds of Ashtabula County, Ohio. The Wilson Bulletin, **45**: 168–195; 1933.

Ohio Department of Natural Resources, Division of Natural Areas and Preserves. Ohio Natural Heritage Program, Special Animals; 1979

Robbins, C.S., B. Bruun, and H.S. Zim. Birds of North America. New York: Golden Press; 1966.

Trautman, Milton B. The fishes of Ohio. Columbus, OH: The Ohio State University Press; 1957.

United States Department of the Interior Geological Survey. East Trumbull Quadrangle, Ohio—Ashtabula County, 7.5 minute series; 1959, photorevised, 1970.

Walker, Charles F. The amphibians of Ohio; part I, frogs and toads. Ohio State Museum Science Bulletin, Vol. I, No. 3, The Ohio Historical Society, Columbus, OH; 1967.

KIRTLANDIA®

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A HERPETOFAUNAL SURVEY OF THE COASTAL ZONE OF NORTHWEST OHIO

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Abstract

A survey of the herpetofauna of the coastal zone of northwest Ohio was conducted from mid-June through late August, 1980. Emphasis was placed on the collection of locality and population size data for *Emydoidea blandingi, Thamnophis sirtalis* (melanistic), *Nerodia sipedon insularum,* and *Elaphe vulpina.* Data were recorded, however, for all herpetofaunal species encountered. Localities within the coastal zone are listed for all reptiles and amphibians seen during the survey. We present our opinions of the present status of the herpetofauna within the coastal zone as well as natural history notes where useful. Several new county records are recorded as well as range extensions. The distribution of the melanistic phase of *Thamnophis sirtalis* within the state is detailed for the first time.

Introduction

The coastal zone of the northwest Ohio end of Lake Erie is of biological interest because it supports the most extensive tracts of marshland in the state. The botanical and ornithological significance of the region is evident, but perhaps less obvious is the fact that this area contains a unique herpetofauna, certain elements of which are rare or lacking in the remainder of the state.

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The marshes are concentrated between Toledo and the eastern end of Sandusky Bay. To the east of this, the marshes become associated mainly with rivers until at approximately the border of Erie and Lorain Counties they become nonexistent and are replaced by a woodland flora more characteristic of northeast Ohio. Here the coastal zone becomes but a thin strip of land for the remainder of its length east to Pennsylvania. Due to extensive development of the narrow coastal zone east of Erie County, coastal habitat in northwest Ohio suitable for supporting a large herpetofauna effectively terminates at the eastern end of Erie County.

Because this region is unique and is undergoing increasing habitat destruction, the Division of Natural Areas and Preserves of the Ohio Department of Natural Resources initiated in 1980, as part of the Ohio Coastal Zone Management Program, several studies dealing with the flora and fauna of the region. Although the herpetological survey was principally concerned with determining the localities in the region of several taxa actually or potentially endangered in the state, data were recorded for all species encountered. The data gathered during the ten weeks of the survey (June-August, 1980) comprise the core of the present report but, when useful, additional notes gathered by us over the past several years are used to supplement these data.

The reptiles and amphibians of the coastal zone, though not specifically dealt with, have been previously included in the works of Conant (1938a, 1951) and Walker (1946). The herpetofauna of the Lake Erie Islands has been well-covered by Langlois (1964). No report, however, has appeared dealing specifically with the herpetofauna of the marshland as a unit. This information would be especially useful because the region has undergone much change since the time of Conant and Walker. The purpose of this report is to provide baseline information on the present-day status and geographic distributions of the species comprising the coastal zone herpetofauna.

Materials and Methods

The geographical scope of the study area is largely confined to within the politically defined boundary of the Ohio Coastal Zone in Lucas, Ottawa, Sandusky, Erie, and extreme western Lorain Counties (Fig. 1). This includes all islands in western Lake Erie under Ohio jurisdiction. Moreover, records, when available, are given for localities in close proximity to this politically defined unit because of the ecological focus of this report.

Surveying consisted primarily of walking along trails, dikes, or through

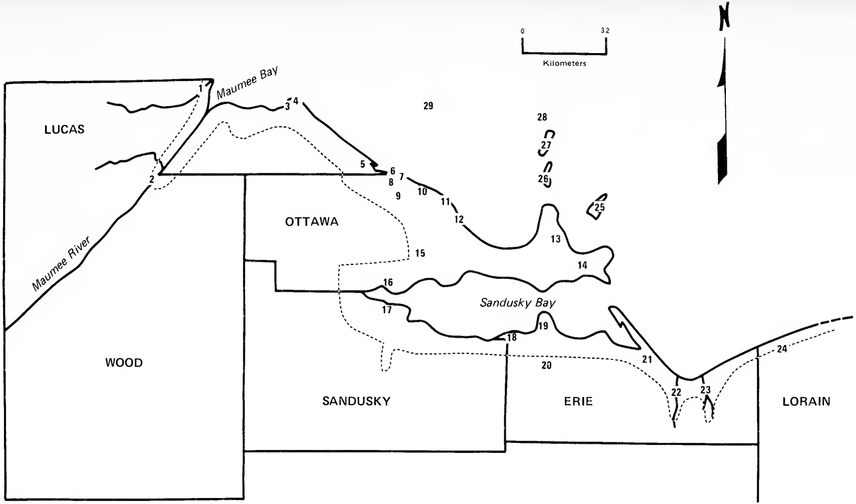

Fig. 1. Collecting sites in Lucas, Ottawa, Sandusky, Erie, and Lorain Counties, Ohio visited during the 1980 ODNR herpetofauna survey. 1–Ottawa River, Toledo; 2–Maumee River Islands; 3–Nile's Woods; 4–Cedar Point NWR; 5–Metzger's Marsh; 6–Crane Creek SP; 7–Magee Marsh; 8–Ottawa NWR; 9–Toussaint Creek WA; 10–Navarre Marsh; 11–Toussaint Shooting Club; 12–Darby Marsh; 13–East Harbor SP; 14–Marblehead Quarries; 15–Little Portage River WA; 16–Winous Point; 17–Ottawa Shooting Club; 18–Willow Point WA; 19–Bayview Marsh; 20–Resthaven WA; 21–Sheldon's Marsh; 22–Huron River; 23–Old Woman's Creek; 24–High Bridge Rd.; 25–Kelleys Island; 26–South Bass Island; 27–Middle Bass Island; 28–North Bass Island; 29–West Sister Island. The area within the dashed line is the coastal zone of Lake Erie in northwest Ohio.

woods, noting the time of each capture or positive identification of a species. Wading along shores or surveying from a canoe was occasionally employed. Cover, when present, was overturned to locate secretive species. Binoculars were often used to observe turtles. Bullfrogs (*Rana catesbeiana*) were often identified by their calls.

When a specimen was captured, its sex and length were noted. Total length was usually estimated to the nearest one inch for lizards and salamanders, two inches for small snakes, and six inches for large snakes. Total length was not generally estimated for turtles. When in the text length is given in metric units, it indicates exact length to the nearest millimeter.

Most specimens captured were released unharmed at the point of capture after the pertinent information was recorded. Specimens from non-protected areas, however, were occasionally preserved for future study or as locality records.

Observations were made throughout the day for many areas, allowing for collection of data on the diel activity of the more abundant species.

In the following, all species captured during the survey are listed (vernacular and scientific names are in accordance with Collins et al., 1982). The localities, dates, and numbers observed are given for each species. Some of the records listed were not observed directly by us but by other sources we considered reputable. Such instances are noted in the species accounts.

If information is available for a species from an area adjacent to the politically defined coastal zone, it is included. (Henceforth, the term "coastal zone" is used interchangeably with "marsh zone" and is intended to denote the more broad ecological and physiographic definition of the region rather than the political definition.)

Included for each species is our impression of its status within the coastal zone. The status is listed as follows:

Abundant–common at numerous localities
Common–present at many localities, density may vary between localities
Uncommon–present at some localities, often restricted in habitat or density; or secretive, and may be present at many localities
Rare–very restricted in range and numbers

Remarks follow for each species, which may include natural history notes and comments on factors leading to the species' status in the coastal zone. Additionally, for species which in Ohio are largely or entirely endemic to the coastal zone (and, therefore, endangered or potentially threatened), we offer suggestions we believe may be effective in reversing the decline of the species' populations or in assuring their continuance within the state.

Following the discussion section of each species is a list of localities within the coastal zone where we did not locate the species but where previous authors have recorded the species.

Description of the Collecting Sites

The western Ohio portion of the Lake Erie coastal zone is composed primarily of marshland with scattered small woods on areas of higher ground. The marshes consist of large expanses of shallow water that locally may form mud flats during the warmer part of the year. Vegetation in these shallow waters consists mainly of emergents. Characteristic are the Nymphaeaceae, *Typha, Alisma, Sagittaria,* and *Potomogeton,* with *Typha* predominating. In areas of deeper water, vascular plants may be lacking altogether. The marshes are transected by numerous dikes which characteristically support a terrestrial early successional stage flora. Characteristic plants include the Cyperaceae, *Gramineae, Cirsium, Asclepias, Plantago, Urtica, Ambrosia, Taraxacum,* and *Daucus.* These dikes are usually earthen, but often overlie a base of limestone boulders which, along the sides of the dikes, provide excellent habitat for certain snake species. Most of the specimens discussed here were found on or adjacent to dikes in the marshes.

On higher ground in some of the marshes small tracts of woods occur, but these are largely unsuitable for habitation by reptiles and few specimens were captured in them. The soil is usually waterlogged and standing water is often present.

Within the coastal zone and distinct from the marshland are the limestone islands north of the Catawba Peninsula, and similar limestone areas on the Marblehead Peninsula of the mainland. The primary habitats on the islands are the rock-strewn shores and inland fields and woods. Additionally, the quarries on Kelleys Island and the Marblehead Peninsula have field and rock ledge habitats unique within the coastal zone.

On the mainland are rocky shores and narrow beach strands. The former is composed primarily of artificial dikes. Beach strand was the predominant form of natural shoreline in the past but is fast disappearing due to action by the lake. In the following the term "shore" indicates a rocky coastal habitat, while "beach" denotes a sandy one.

Within the coastal zone most tracts of land large enough to be of significance in supporting large reptile and amphibian populations are owned by the federal or state governments or by private hunting clubs. Otherwise, most of the remaining land in the coastal zone does not consist of sufficiently large tracts of suitable habitat and was not visited in this survey.

The localities studied, their acreage, and major habitats follow. Locations are shown in Figure 1. The Ottawa National Wildlife Refuge is composed of five units which shall be referred to separately; "Ottawa NWR" designates the largest unit wherein is located the refuge headquarters. Abbreviations used are NWR for National Wildlife Refuge, SP for State Park, and WA for Wildlife Area.

(1) Ottawa River, Toledo, Lucas Co. (80)–fields, riverine cattail marsh
(2) Maumee River islands, Lucas Co. (200)–woods, riverine marsh
(3) Nile's Woods, Lucas Co. (1241)–shore, fields, cattail marsh, woods
(4) Cedar Point NWR, Lucas Co. (2245)–marsh, woods, beach
(5) Metzger's Marsh, Lucas Co. (558)–shore
(6) Crane Creek SP, Lucas and Ottawa Cos. (72)–marsh, beach, woods
(7) Magee Marsh, Ottawa Co. (2131)–marsh, beach, woods
(8) Ottawa NWR, Lucas and Ottawa Cos. (4683)–marsh, shore, woods, beach
(9) Toussaint Creek WA, Ottawa Co. (236)–marsh
(10) Navarre Marsh, Ottawa Co. (591)–marsh, beach, woods
(11) Toussaint Shooting Club, Ottawa Co. (1800)–marsh, beach
(12) Darby Marsh, Ottawa Co. (520)–marsh, shore
(13) East Harbor SP, Ottawa Co. (1691)–beach, marsh, woods
(14) Marblehead Quarries, Ottawa Co. (2500)–limestone outcrops and fields
(15) Little Portage River WA, Ottawa Co. (357)–marsh
(16) Winous Point, Ottawa Co. (4500)–marsh, shore, woods
(17) Ottawa Shooting Club, Sandusky Co. (3500)–marsh, woods
(18) Willow Point WA, Erie Co. (645)–marsh, shore, woods
(19) Bay View Marsh, Erie Co. (1175)–marsh
(20) Resthaven WA, Erie Co. (2210)–woods, fields
(21) Sheldon's Marsh, Erie Co. (386)–marsh, beach, woods
(22) Huron River, Erie Co. (500)–fields, riverine marsh, and woods
(23) Old Woman's Creek, Erie Co. (640)–fields, riverine marsh, and woods
(24) High Bridge Rd., Lorain Co. (80)–woods, fields
(25) Kelleys Island, Erie Co. (2797)–limestone outcrops, fields, woods
(26) South Bass Island, Ottawa Co. (1570)–shore, fields, woods
(27) Middle Bass Island, Ottawa Co. (813)–shore, fields, woods
(28) North Bass Island, Ottawa Co. (704)–shore, fields, woods
(29) West Sister Island, Lucas Co. (80)–shore, woods

Species Accounts

Ambystoma tigrinum tigrinum (Eastern Tiger Salamander)

Kelleys Island, 8-19-80 (1), 7-23-81 (6). *Rare*

The 1980 specimen was captured under a piece of wet cardboard in short grass near the quarry at the center of the island; all others were found in or adjacent to rock slides. We are aware of other recent specimens from the island and Langlois (1964) records them from South Bass Island and Middle Bass Island.

Ambystoma maculatum (Spotted Salamander)

High Bridge Rd., Lorain Co., 7-23-80 (6). *Rare*

Located in late morning under railroad ties adjacent to a mesic woods. All specimens were adults.

Recorded from South Bass Island by Langlois (1964).

Ambystoma texanum (Smallmouth Salamander)

Ottawa River, Toledo, 4-11-80 (1); Middle Bass Island, 6-8-80 (1). *Rare*

The first specimen was found along a ditch, the second along the east shore of Middle Bass Island. This species occurs primarily in populations composed largely of hybrids between this species and *A. laterale.*

Downs (1978) records this species as relatively rare on Middle Bass Island. Other literature records are questionable due to the tendency for this species to form hybrids in this region and the difficulty of separating *A. texanum* from the hybrids.

Ambystoma hybrids

Ottawa River, Toledo, 3-20-80 (1); Pearson Park, 5-9-80 (5); East Harbor SP, 6-26-80 (2), 8-14-80 (8); Sheldon's Marsh, 7-15-80 (1); High Bridge Rd., Lorain Co., 7-23-80 (1), 6-28-81 (1); Kelleys Island, 8-19-80 (3); Middle Bass Island, 6-7-80 (2). *Uncommon*

These are hybrids between *A. texanum* and *A. laterale* (see Downs, 1978) and, on Kelleys Island, between *A. texanum* and *A. tigrinum.* Furthermore, the Lorain Co. specimens may be hybrids between *A. texanum* and *A. jeffersonianum* as Uzzell (1964) records *A. jeffersonianum* from within a couple miles of this site.

The Pearson Park locality is 3 mi. east of the Toledo city boundary.

All specimens were found in mesic conditions, often in or adjacent to woods that were subject to flooding. Though not easily located, these salamanders probably have a more extensive range within the coastal zone than presently indicated. However, their distribution will no doubt prove to be discontinuous due to the isolated occurrence of their wooded habitat throughout much of the marsh zone.

Downs (1978) also records these salamanders from Middle Bass Island and North Bass Island.

Plethodon cinereus (Redbacked Salamander)

East Harbor SP, 6-26-80 (1); Sheldon's Marsh, 8-22-80 (2); High Bridge Rd., Lorain Co., 7-23-80 (5). *Uncommon*

All specimens were found in mesic situations in or adjacent to woods. The species was only recorded from the eastern half of the study zone, where somewhat higher elevations occur and woodlands are more prevalent.

This species has been recorded from South Bass Island (Langlois 1964).

Plethodon glutinosus glutinosus (Slimy Salamander)

Old Woman's Creek, 7-8-80 (1). *Rare*

One specimen was found under a log on a dry westward-facing hillside, adjacent to the river. The specimen measured 74 mm S-V length and was a female. This probably represents the westward-most extension of the species in northern Ohio.

Bufo americanus americanus (Eastern American Toad)

Ottawa River, Toledo, 6-19-80 (1); East Harbor SP, 7-7-80 (1); Marblehead Quarries, 8-14-80 (>20); Winous Point, 7-25-80 (1); Ottawa Shooting Club, 8-4-80 (3); Willow Point WA, 8-12-80 (1); Resthaven WA, 8-1-80 (1); Castalia, 8-13-80 (1); Sheldon's Marsh, 8-22-80 (3); Huron River, 8-8-80 (2); Old Woman's Creek, 7-9-80 (2); High Bridge Rd., Lorain Co., 7-23-80 (4); Kelleys Island, 8-19-80 (6). *Uncommon*

Although this species was found at several localities in the coastal zone, it appeared common at only two localities. Fields, beaches, and woods were occupied, though quarry fields produced the most individuals.

The Ottawa Shooting Club locality represents a new county record for the species.

It has previously been found in the coastal zone at Port Clinton, Ottawa Co.; and on Gibralter Island, Middle Bass Island, and South Bass Island (Walker 1946).

Bufo woodhousei fowleri (Fowler's Toad)

Crane Creek SP, 6-17-80 (1); East Harbor SP, 6-26-80 (2), 7-7-80 (1); Old Woman's Creek, 7-9-80 (2). *Rare*

This species was not commonly seen during the survey. The specimens at the first two localities were on beaches; the last locality was a field.

The species has previously been recorded in the coastal zone near Castalia and at Cedar Point, Erie Co.; and at Port Clinton and on the Marblehead Peninsula, Ottawa Co. (Walker 1946).

Acris crepitans blanchardi (Blanchard's Cricket Frog)

Ottawa Shooting Club, 8-12-80 (3); Middle Bass Island, 7-25-80 (1). *Rare*

The specimens at the first locality were on a grassy dike adjacent to marshland; the one from the second locality was in a woodland pond.

Previously recorded from Castalia and Sandusky, Erie Co.; and North Bass Island by Walker (1946).

Rana catesbeiana (Bullfrog)

Cedar Point NWR, 6-23-80 (3), 7-14-80 (1); Ottawa NWR, 6-20-80 (1); Crane Creek SP, 6-17-80 (1); Magee Marsh, 4-27-74 (2); Toussaint Creek WA, 6-30-80 (3), 8-13-80 (1), 5-16-80 (1); Navarre Marsh, 6-27-80 (1); Darby Marsh, 7-1-80 (1); Old Woman's Creek, 7-8-80 (2); Middle Bass Island, 7-3-80 (1), 7-25-80 (1). *Common*

This species is a characteristic denizen of the marshes in the coastal zone and is doubtless more widespread and abundant than indicated by our data. Due to the species' habit of frequenting offshore areas, most of the above records are counts of calling individuals.

The Old Woman's Creek locality may represent a new county record for the species.

The bullfrog has been previously recorded in Ottawa Co. at Camp Perry, Lakeside, East Harbor, and South Bass Island by Walker (1946) and Gibralter Island by Langlois (1964).

Rana clamitans melanota (Green Frog)

Toussaint Creek WA, 8-20-80 (1); Navarre Marsh, 6-27-80 (1);

Marblehead Quarries, 8-14-80 (1); Ottawa Shooting Club, 6-6-81 (1); High Bridge Rd., Lorain Co., 7-23-80 (1), 6-28-81 (2). *Uncommon*

The apparent rarity of this species in the coastal zone may be actual or an artifact of our sampling methods in the habitat occupied by the species in this area. If, like the bullfrog, it inhabits primarily deeper water in the marshes, the species may be common yet remain unnoticed. Walker (1946) records the species as absent from the coastal zone except for Townsend Twp., Sandusky Co. and an old record from Castalia, Erie Co. by Morse (1904). The Toussaint Creek, Navarre Marsh, and Marblehead Quarries records represent the first definite locality records for Ottawa Co. The first two localities are marsh, the third field and limestone outcrop, and the fourth woods.

Rana pipiens (Northern Leopard Frog)

Ottawa River, Toledo, 6-19-80 (1), 7-19-81 (>20); Cedar Point NWR, 6-23-80 (1), 7-9-80 (1), 7-14-80 (4); Ottawa NWR, 6-20-80 (1), 6-24-80 (1); Crane Creek SP, 6-17-80 (2); Magee Marsh, 6-16-80 (5), 6-18-80 (2); Toussaint Creek WA, 8-13-80 (>20), 8-20-80 (>80); Navarre Marsh, 6-25-80 (1); Darby Marsh, 7-1-80 (2); East Harbor SP, 6-26-80 (3); Little Portage River WA, 7-18-80 (5), 8-11-80 (>20); Winous Point, 7-25-80 (>50), 8-21-80 (>50); Ottawa Shooting Club, 8-12-80 (>20); Willow Point WA, 7-30-80 (1); Bay View Marsh, 7-24-80 (>30); High Bridge Rd., Lorain Co., 6-28-81 (1); Kelleys Island, 8-19-80 (1). *Abundant*

This is at times an incredibly abundant frog in the marshes; at other times it may appear rare or absent. It occurs most commonly in areas of high grass and is most frequently found on the dikes during very hot weather. Under such prime conditions frogs may occur every few feet. The species is characteristic of the marsh zone and a very important link in the trophic structure of the marsh community.

At Winous Point on 8-21-80 several of these frogs were heard giving distress calls in the grass. Investigation invariably determined the caller to be in the process of being swallowed by *Thamnophis sirtalis.* Since our investigation into the matter several times caused the snakes to release their prey, the utility of the distress call is obvious. It would be interesting if the distress call served the same purpose naturally, by attracting other species to the disturbance to effect release of the prey.

Additionally, the species has been reported from Cedar Point, Erie Co.; the Marblehead Peninsula, and South Bass, Middle Bass, North Bass, and West Sister Islands by Walker (1946).

Rana sylvatica (Wood Frog)

High Bridge Rd., Lorain Co., 7-23-80 (5). *Rare*

This species appears totally absent from the marsh areas, although Morse (1904) recorded it as present at Sandusky, Erie Co. The above specimens were found in a wooded situation within the coastal zone but east of the extensive zone of marshland.

Chelydra serpentina serpentina (Common Snapping Turtle)

Cedar Point NWR, 6-30-80 (1); Metzger's Marsh, 5-29-81 (1); Magee Marsh, 6-16-80 (1); East Harbor SP; Winous Point; Ottawa Shooting Club, 8-4-80 (1); Willow Point WA, 7-30-80 (1), 5-16-81 (1). *Common*

We list the status of this species in the marsh zone as common, despite the few records available, because of its secretive, highly aquatic habits. These turtles characteristically lie submerged on the marsh substrate except when surfacing for air or, very rarely, sunning. Of the above records, three were sightings of dead animals, two of surfacing animals, and one of a basking animal. The Winous Point locality is based on the experience of manager Dr. Bob Meeks, who often captures the species in traps. Similarly, the East Harbor locality is based on a specimen captured there by park personnel and observed by us. Because this species frequents both marshes and ditches we have no doubt that it ranges widely throughout the coastal zone, despite the difficulty of its detection without the use of traps.

The Ottawa Shooting Club specimen represents a new county record.

The species has previously been recorded in the coastal zone at Sandusky, Erie Co.; Erie Twp., and South Bass Island, Ottawa Co.; and Bono, Lucas Co. (Conant 1938a).

Emydoidea blandingi (Blanding's Turtle)

Nile's Woods, 6-18-80 (4); Cedar Point NWR, 6-23-80 (2), 7-9-80 (1), 7-14-80 (1); Ottawa NWR, 6-20-80 (5); Crane Creek SP, 6-17-80 (3); Magee Marsh,.6-16-80 (3); Navarre Marsh, 6-25-80 (2), 6-27-80 (2); Toussaint Shooting Club, 7-28-80 (8), 7-29-80 (1); Darby Marsh, 7-1-80 (1); East Harbor SP, 7-7-80 (3); Winous Point; Ottawa Shooting Club, 8-4-80 (5); Willow Point WA, 8-12-80 (1); Old Woman's Creek, 7-8-80 (1); Middle Bass Island, 6-8-80 (1). *Common*

Due to this species' restricted geographic range in Ohio, this was one of the species of interest to the ODNR during the reptile survey. This species, like *Chelydra,* is mainly aquatic and basks infrequently. For this reason the species may be common in an area, yet go unnoticed. This is exemplified at Winous Point where we located no specimens although they have been frequently captured in turtle traps by manager Dr. Bob Meeks. Similarly, at the Toussaint Shooting Club, only one of the nine specimens was a sight record; the other eight were accidently captured in fish nets maintained by club members and would have been overlooked by us otherwise. Additionally, the East Harbor SP locality record is based on specimens captured by park personnel and retained in captivity there for the summer.

Our records seem to indicate that when this species basks, it is more or less constant throughout the day from 1000 h to 1800 h, with no apparent peak of activity. Only one specimen was observed before 1000 h. Basking is usually done on logs, but some specimens were observed to bask by floating on the surface of the water.

Three females were captured on land. One was making a nest on 7-14-80. The other two were captured on 6-18-80 and 7-1-80, presumably in some stage of the egg-laying process.

Hatchlings and juveniles were never seen by us. All specimens were large adults or ca. 6-in. subadults. Possibly juveniles are rare or totally aquatic, though we may have overlooked basking individuals. We consider the latter unlikely since small *Chrysemys* were easily spotted under such conditions.

Because this species is aquatic, lacks commercial value, and occupies protected lands, it will likely not suffer drastic population declines in the marsh zone of Ohio.

This species has been recorded from Cedar Point and Sandusky, Erie Co.; Green Island, Ottawa Co.; and Bono, Lucas Co. by Conant (1938a) and on North Bass Island and South Bass Island by Langlois (1964).

Chrysemys picta marginata (Midland Painted Turtle)

Ottawa River, Toledo, 6-19-80 (1); Maumee River Islands, 8-7-80 (1); Nile's Woods, 8-11-80 (1); Cedar Point NWR, 6-23-80 (13), 7-14-80 (3); Metzger's Marsh, 6-18-80 (1); Ottawa NWR, 6-20-80 (27), 6-24-80 (10), 5-29-81 (2); Crane Creek SP, 6-17-80 (42); Magee Marsh, 6-16-80

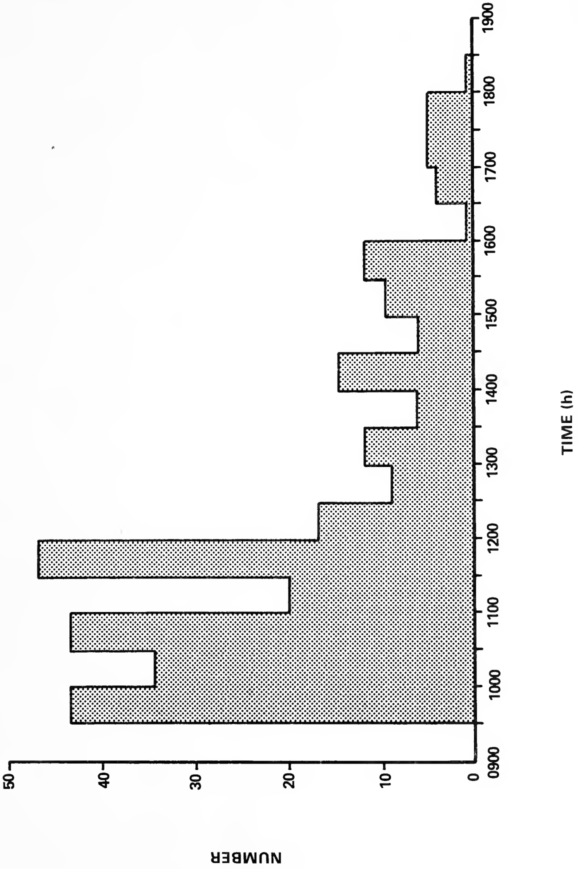

Fig. 2. Basking activity of *Chrysemys picta marginata*.

(12), 6-18-80 (2); Toussaint Creek WA, 6-30-80 (2), 8-13-80 (35); Navarre Marsh, 6-25-80 (16), 6-27-80 (16); Toussaint Shooting Club, 7-28-80 (1), 7-29-80 (1); Darby Marsh, 7-1-80 (12); East Harbor SP, 6-26-80 (2), 7-7-80 (4); Little Portage River WA, 7-18-80 (5); Winous Point, 7-25-80 (6), 8-21-80 (44); Ottawa Shooting Club, 8-4-80 (14), 8-12-80 (3); Willow Point WA, 7-30-80 (3); Resthaven WA, 6-6-80 (1); Bay View Marsh, 7-24-80 (1), 8-4-80 (1); Sheldon's Marsh, 7-15-80 (4); Old Woman's Creek, 7-8-80 (6); Middle Bass Island, 7-3-80 (2), 7-25-80 (6). *Abundant*

This is one of the most common reptiles of the marsh zone. It was seen basking on any day with full sun. Our data (Fig. 2) indicate a peak in basking activity between 0930 h to 1200 h, with lowered but fairly constant activity between 1200 h to 1600 h, and a decline after 1600 h. Basking individuals were never seen before 0930 h. We feel this is not an artifact of collecting, due to our usual presence in the field before that time.

Two females were observed laying eggs, one each on 6-18-80 and 6-25-80, and three females were making nests, one on 6-16-80 and two on 5-29-81.

Additional localities include South Bass Island (Langlois 1964) and North Bass Island (Conant 1938a).

Graptemys geographica (Map Turtle)

Nile's Woods, 8-11-80 (1); Winous Point; Old Woman's Creek, 7-8-80 (2). *Rare*

Albeit our records indicate the map turtle to be rare in the coastal zone, this may be due to the species' shyness, and we assume it to be actually somewhat more abundant than it presently appears. This assumption is reinforced by data from Conant (1938a) which indicate the species to be more widespread in the coastal zone than our observations do. Its apparent rarity is due to the fact that it often frequents deep water and readily takes alarm at disturbances.

The Nile's Woods specimen was seen in a large ditch adjacent to marshland. The Old Woman's Creek specimens were found in a river. At Winous Point, the species frequents marshland and has been observed there by manager Dr. Bob Meeks.

Conant (1938a) records the species from Sandusky and Sandusky Bay, Erie Co.; the mouth of the Sandusky River, Sandusky Co.; the Toussaint River, Port Clinton, the Catawba Peninsula, and South Bass Island, Ottawa Co.; and Bono, Lucas Co.

Trionvx spiniferus spiniferus (Eastern Spiny Softshelled)

Winous Point; Huron River, 8-5-80 (1). *Rare*

The Huron River specimen was a juvenile found basking on a log next to a dense thicket of emergents in a still, shallow section of the river. This species is largely an inhabitant of rivers and was not observed by us in marsh situations. Dr. Meeks has seen one specimen collected at the mouth of the Sandusky River, Winous Point.

The species was previously recorded in the coastal zone at Sandusky, Erie Co.; East Harbor, Ottawa Co.; and Reno Beach, Lucas Co. by Conant (1938a). It remains unrecorded from the Lake Erie Islands.

Eumeces fasciatus (Five-Lined Skink)

Crane Creek SP, 8-31-69 (1), 9-14-69 (1), 9-28-69 (1); Navarre Marsh, 6-25-80 (2), 6-27-80 (7); Castalia, 8-13-80 (5), 6-6-81 (1); Resthaven WA, 8-1-80 (2). *Rare*

This species is quite rare in the marsh zone, in part because of its predilection for wooded environs. We have not seen this species at Crane Creek SP in over a decade, although we have received reliable reports of its continued persistence there. A population at adjacent Magee Marsh appears to have been extirpated by human activity roughly ten years ago. Another reason for the disappearance of this species in the marsh zone is the recent destruction by the lake of beach strand woods, its favored habitat in this area. Specimens were found in this habitat at Navarre Marsh and previously at Crane Creek SP (the Crane Creek SP beach strand woods are now eliminated).

The Navarre Marsh locality represents a new county record. The species has been found in the coastal zone previously at Reno, Lucas Co. (Conant 1938a) and near Vickery, Sandusky Co. (Britt 1957).

Nerodia sipedon sipedon (Northern Water Snake)

Nile's Woods, 7-4-80 (4); Cedar Point NWR, 6-23-80 (1), 7-9-80 (4), 7-14-80 (3); Metzger's Marsh, 5-19-81 (4); Ottawa NWR, 6-20-80 (18), 6-24-80 (8); Crane Creek SP, 5-24-69 (2); Magee Marsh, 6-16-80 (3), 6-18-80 (2); Toussaint Creek WA, 6-30-80 (1), 8-13-80 (1), 8-20-80 (1), 5-16-80 (7); Navarre Marsh, 6-25-80 (1), 6-27-80 (1); Toussaint Shooting Club, 7-28-80 (16), 7-29-80 (10), 8-3-80 (19); Darby Marsh, 7-1-80 (4); East Harbor SP, 7-7-80 (1); Marblehead Quarries, 8-14-80 (1); Marblehead Peninsula, 4-27-74 (1); Little Portage River WA, 8-1-80 (3), 5-16-81 (6); Winous Point, 7-25-80 (2); Ottawa Shooting Club, 8-12-80 (1); Willow Point WA, 7-30-80 (5), 5-16-81 (16); Bay View

Marsh, 7-24-80 (3), 8-4-80 (1); Resthaven WA, 8-1-80 (1); Sheldon's Marsh, 7-15-80 (1); Huron River, 8-5-80 (7); Old Woman's Creek, 7-8-80 (3), 7-9-80 (5); Middle Bass Island, 6-24-79 (3), 7-28-79 (3), 7-3-80 (2); North Bass Island, 7-11-80 (1). *Abundant*

Nerodia sipedon has two subspecies found in the coastal zone, the nominate form and *N. s. insularum,* which follows. This subspecies is quite abundant on the mainland and is less abundant on the Lake Erie Islands. It is only rarely found far from water, and in the marsh zone a favorite habitat, when available, is the boulder piles projecting from the sides of numerous dikes. They also often bask next to the water on the grassy sides of the dikes or on overhanging branches and brush piles.

Our records indicate that specimens may be found in low numbers throughout the day but their numbers increase between 1100 and 1330 h due to basking activity; a second peak in numbers occurs between 1500 and 1530 h (Fig. 3).

The specimens from the marsh zone typically have a very dark gray dorsum, with the bands becoming obscured with age, and a cream venter which becomes suffused posteriorly with increasing amounts of dark gray until the posterior one-third or one-half is solid gray.

Two specimens were found on the mainland which differ from this typical condition. The first was a gravid female with normal dorsal coloration but with a bright red-orange venter with no gray stippling. On 9-4-80 she bore 29 offspring, many of which had a light orange streak down the mid-venter but with white on the edges. The second was an intergrade between *sipedon* and *insularum* of the "C" phenotype (see Conant and Clay 1937 for phenotype descriptions) from the Marblehead Peninsula. This form occurs at low frequency on the Marblehead Peninsula (Conant and Clay 1937), and was not an unexpected find. On 9-8-80 it bore 16 offspring, all of which were banded. Intergradation between *sipedon* and *insularum* will be considered in more detail in the next species account.

On 5-16-81, four males courting a large female were observed at Willow Point WA. The female was *in copula* with one male while the others were engaged in dorsal chin-rubbing, dorsal forward-advancement, and tail-search copulatory attempts (Gillingham 1979). No aggression between the males was observed. Reproductive behavior of this type has been described for *N. s. insularum* (Langlois 1964) and for other natricine snakes (Aleksiuk and Gregory 1974). The above snakes were

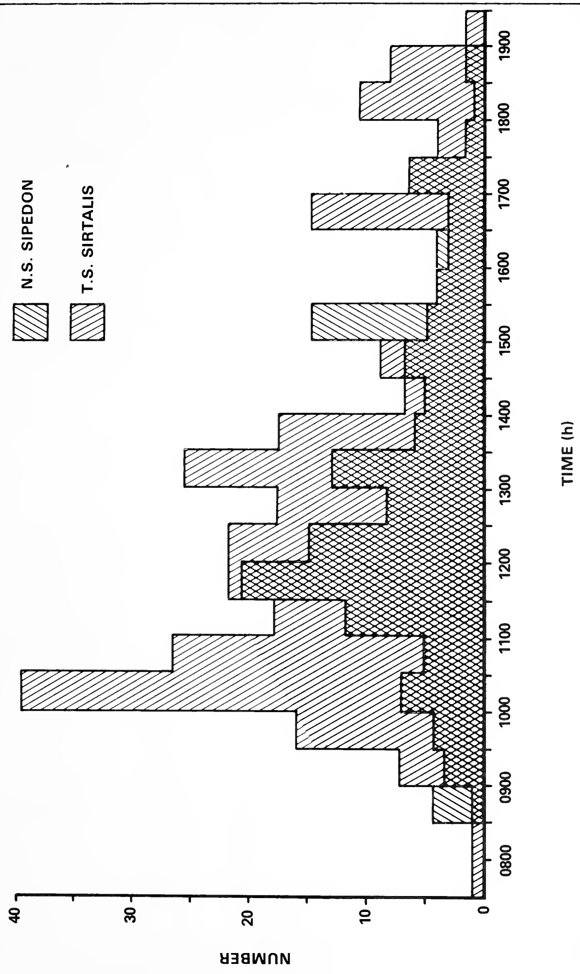

Fig. 3. Observation times of *Nerodia s. sipedon* and *Thamnophis s. sirtalis.*

found on tree branches two feet above the water ca. 6 ft from shore at 1530 h on a warm, sunny day.

Localities listed by Conant (1938a) are largely contained within or adjacent to our localities, except for Mouse Island, which we did not visit.

Nerodia sipedon insularum (Lake Erie Water Snake)

South Bass Island, 6-14-79 (4); Middle Bass Island, 6-24-79 (13), 7-30-80 (11), 7-28-80 (12), 7-29-80 (1); North Bass Island, 6-11-80 (10); Kelleys Island; East Harbor SP, 7-80 (1). *Rare*

This subspecies is largely restricted to the Lake Erie Islands of Ohio and Ontario but occurs in very small numbers on the adjacent Catawba and Marblehead peninsulas of Ohio (Conant and Clay 1937). It is limited in habitat primarily to the rocky shorelines, but does occasionally inhabit more inland environs.

We consider *"insularum"* to include only those specimens lacking (or nearly lacking) dorsal and ventral patterns (designated as "A" by Conant and Clay, 1937) and not the phenotypes ("ab," "B," "bc," "C," "cd," and "D") exhibiting dorsal and ventral patterns (Conant and Clay 1937; Camin et al. 1954) (however, see Conant and Clay 1963, for an alternative opinion). Of the latter group, "D" designates typical *N. s. sipedon*; the remainder are intermediate phenotypes between *insularum* and *sipedon.*

With this understanding of what we consider to be pure *insularum,* only 14 specimens of this subspecies have been observed during these two years; however, somewhat larger numbers of the patterned phenotypes have been observed during the same period. Regardless of the taxonomic designations, the population densities of insular *Nerodia* have been drastically reduced over the past 40 years. Conant and Clay (1937) and Camin and Ehrlich (1958) reported collecting on a single island 234 and over 400 *Nerodia,* respectively, each within the span of a few hours in a single day. It is now doubtful whether these numbers of *Nerodia* could be found in an entire summer of intensive collecting on the islands.

The largest number collected by us on a single island were from Middle Bass Island. Of a total of 37 specimens collected, only 11 (30%) were identified as *insularum,* 18 (49%) were identified as intermediates, and 8 (21%) were indistinguishable from typical Ohio mainland *sipedon* from the marsh areas. Conant and Clay (1937) reported that of 51

Nerodia collected from Middle Bass Island, 27.5% were "A," 62.8% were "B" and "C," and 9.7% were "D."

On North Bass Island 10 specimens were collected: 2 (20%) were identified as *insularum,* 7 (70%) were identified as intermediates, and 1 (10%) was a *sipedon.*

On South Bass Island 4 specimens were collected; all were intermediates ("bc"-"C").

The Kelleys Island record is based on the observations of Richard King, who is presently studying the populations of this subspecies. We were unable to locate specimens on this island during our visits.

In East Harbor SP, a specimen of *insularum* (adult female) was collected by Doug Ceraldi and kindly given to us for study. Although this specimen lacked dorsal and ventral patterns, it was unusually dark for *insularum.* On 8-30-80, she bore 26 offspring, 2 of which were *insularum*; the remainder were patterned.

Reproductive activity was not observed by us but had been observed by Langlois (1964) in May. Hamilton (1951) observed female "*insularum*" to be first noticeably pregnant in May, and to range in size from 571 mm to 921 mm. The number of embryos per female ranged from 8 to 26, and a brood of 27 was observed. Parturition occurs in late summer and autumn.

We observed several neonate *Nerodia* on Middle Bass Island with ingested *Notropis* spp. Other reported food items include fish (*Percina,* cyprinids, *Cottus*) and amphibians (*Rana pipiens, R. clamitans, Bufo* spp., *Necturus*) (Hamilton 1951; Langlois 1964).

On the shoreline of South Bass Island, which is largely developed with houses, the preferred habitat of *Nerodia* is nearly eliminated, and we seriously doubt the island can once again support even a moderately sized population. After a search of most of the island, we located only one narrow stretch of shoreline of ca. 200 yd length which appeared potentially suitable for *Nerodia.* We collected only 4 water snakes and, due to the suboptimal conditions of the habitat, this area can likely support only few more.

Middle Bass Island, though presently supporting a moderately sized population of *Nerodia,* is in the process of becoming like South Bass Island. This is due to increased building and clearing activities along the shoreline and the increased influx of tourists on the island. Both factors are contributing to the degradation of the shoreline habitat that *Nerodia* inhabits.

On Kelleys Island we could not locate any suitable shoreline habitat; however, it was not possible to search the entire island in the short time available.

Only on North Bass Island did there appear to be extensive areas of shoreline suitable for *Nerodia.* Additionally, the snakes appeared to be relatively free of human harassment.

Because of the increasing lack of habitat for all *Nerodia* on the larger Ohio islands, the increasing harassment from tourists on some of the islands, and the increasingly greater proportion of *N. s. sipedon* and intermediates on the islands, we believe the status of *N. s. insularum* to be extremely precarious. We therefore highly recommend official protection of the subspecies by the state of Ohio. We feel it would be of additional benefit to this subspecies if agreements between the ODNR and the owners of the private islands (for example, Green, Rattlesnake, North Bass) were reached concerning the protection of all insular *Nerodia* on these islands. Moreover, a public education program for the residents of the other islands may be useful.

Regina septemvittata (Queen Snake)

Cedar Point NWR, 7-14-80 (1); Ottawa NWR, 6-20-80 (1); Crane Creek SP, 4-4-69 (1); Magee Marsh, 5-6-79 (1); Toussaint Shooting Club, 7-28-80 (1), 7-29-80 (2); Willow Point WA, 5-16-81 (3); Resthaven WA, 8-1-80 (2); Huron River, 8-5-80 (1); Kelleys Island. *Uncommon*

This species is no doubt more widespread in the marsh zone than our records indicate. It is often rather secretive and some of our specimens were found hiding under cover. Most, however, were seen basking on branches overhanging the water. Such specimens were usually gravid females.

The specimen from Kelleys Island was observed by Richard King in 1980 and is the first record of this species from any of the Lake Erie Islands.

Conant (1938a) records this species at Sandusky, Erie Co.; and Green Creek, Sandusky Co.

Clonophis kirtlandi (Kirtland's Snake)

Cedar Point NWR, 7-14-80 (1). *Rare*

The above specimen was an adult male. We are also aware of one dead and three live specimens taken from the same locality in the past six years.

Conant (1938a) has recorded this species from Nile's Woods, Lucas Co.; 6 mi NE of Fremont, Sandusky Co.; and Sandusky, Erie Co. It has not yet been reliably recorded from the Lake Erie Islands.

Thamnophis butleri (Butler's Garter Snake)

Ottawa River, Toledo, 6-19-80 (10); Nile's Woods, 6-18-80 (1), 7-4-80 (2), 8-11-80 (1); Cedar Point NWR, 7-14-80 (3); Ottawa NWR, 6-2-80 (3), 6-24-80 (1), 5-29-81 (3); Crane Creek SP, 6-17-80 (1); Magee Marsh, 6-16-80 (2); Little Portage River WA, 7-18-80 (1), 5-16-81 (>10); Ottawa Shooting Club, 8-12-80 (1). *Uncommon*

This species is locally common in some parts of the marsh zone but is rare or absent in others. Although this species is usually less abundant than *T. s. sirtalis* when the two occur in the same locality, there are a few localities where *sirtalis,* an abundant snake in this region, is largely replaced by *butleri.*

The specimen from the Ottawa Shooting Club represents a new county record.

Conant (1938a) also records this species from Sandusky, Erie Co.; Port Clinton, Ottawa Co.; and Bono and Reno Beach, Lucas Co. This species has not yet been recorded from the Lake Erie Islands.

Thamnophis sirtalis sirtalis (Eastern Garter Snake–striped phase)

Ottawa River, Toledo, 6-5-81 (1); Nile's Woods, 6-18-80 (9), 7-4-80 (3), 7-21-80 (2); Cedar Point NWR, 6-23-80 (4), 6-30-80 (3), 7-9-80 (2), 7-14-80 (2); Metzger's Marsh, 5-19-80 (2), 6-18-80 (1); Ottawa NWR, 6-20-80 (24), 6-24-80 (12); Crane Creek SP, 6-17-80 (14); Magee Marsh, 6-16-80 (19), 6-18-80 (8); Toussaint Creek WA, (11), 8-13-80 (5), 5-16-81 (15); Navarre Marsh, 6-25-80 (10), 6-27-80 (4); Darby Marsh, 7-1-80 (5); East Harbor SP, 6-26-80 (3), 7-7-80 (7); Marblehead Quarries, 7-7-80 (1), 8-14-80 (3); Bay Point, Marblehead, 7-21-80 (1); Little Portage River WA, 8-1-80 (1), 8-11-80 (5), 5-16-81 (2); Winous Point, 7-25-80 (2), 8-21-80 (7); Ottawa Shooting Club, 8-4-80 (6), 8-12-80 (12); Willow Point WA, 7-30-80 (8), 5-16-81 (15); Bay View Marsh, 7-24-80 (3), 7-30-80 (1); Sheldon's Marsh, 7-15-80 (1), 8-22-80 (1); Huron River, 8-5-80 (1), 8-8-80 (6); Old Woman's Creek, 7-9-80 (16); High Bridge Rd., Lorain Co., 7-23-80 (2); South Bass Island, 6-14-79 (1); Middle Bass Island, 7-3-80 (15); North Bass Island, 7-11-80 (4); West Sister Island, 5-13-81 (13). *Abundant*

This was the most common species of reptile in the coastal zone. It was found in all major habitats, but it attained its highest densities in grassy marsh or field areas.

As can be seen from Figure 3, *T. s. sirtalis* was most active between 0930 h and 1400 h (71% of sightings) with less activity apparent at other times of the day and a smaller peak between 1630 h and 1900 h (15% of sightings). Its peak activity takes place earlier than *N. s. sipedon,* the other dominant natricine member of the marsh zone herpetofauna.

The most important food for this species in the marsh zone is frogs and fish; several specimens of *T. sirtalis* were located during the survey in the process of devouring the former (see remarks under *Rana pipiens*). On 5-16-81, one individual of this species was found with a piece of a *Microtis* carcass in its mouth. Upon capture, examination revealed another partial *Microtis* in its stomach.

Due to the ubiquitous presence of this species in the coastal zone, there is little point in including localities mentioned by other authors.

Thamnophis sirtalis sirtalis (Eastern Garter Snake-melanistic phase)

Wildwood Metropark, 4-17-80 (1); Medical College of Ohio, 6-18-75 (1); Nile's Woods, 6-18-80 (2), 7-4-80 (1), 7-21-80 (1); Cedar Point NWR, 6-30-80 (1), 7-9-80 (3), 7-14-80 (1); Ottawa NWR, 6-20-80 (2), 6-24-80 (1); Crane Creek SP, 6-17-80 (1); Magee Marsh, 6-16-80 (3); Toussaint Creek WA, 6-15-81 (2); Navarre Marsh, 6-25-80 (5), 6-27-80 (1); Camp Perry, 4-26-81 (1); Darby Marsh, 7-1-80 (4); East Harbor SP; Little Portage River WA, 5-16-81 (2); Winous Point, 7-25-80 (1), 8-21-80 (2), 6-6-81 (1); Ottawa Shooting Club, 8-4-80 (2), 8-12-80 (3), 6-6-81 (1); Willow Point WA, 5-16-81 (1); Sheldon's Marsh, 8-2-80 (1); Old Woman's Creek; Kelleys Island, 8-19-80 (1); Middle Bass Island, 7-3-80 (2), 5-30-81 (4); West Sister Island, 5-13-81 (2). *Rare*

These snakes are a recessive color phase of the widespread *T. s. sirtalis* and are restricted in Ohio to the marsh zone of western Lake Erie and its immediate environs. The Mendelian inheritance pattern was established by Blanchard and Blanchard (1941). Where found, this phase occurs at low to moderate densities.

Because the range of this color morph in Ohio has not previously been precisely ascertained, we include all localities for the form known to us, both within and out of the coastal zone (Fig. 4). It is apparent, however, that this phenotype is mainly restricted to the marsh zone and

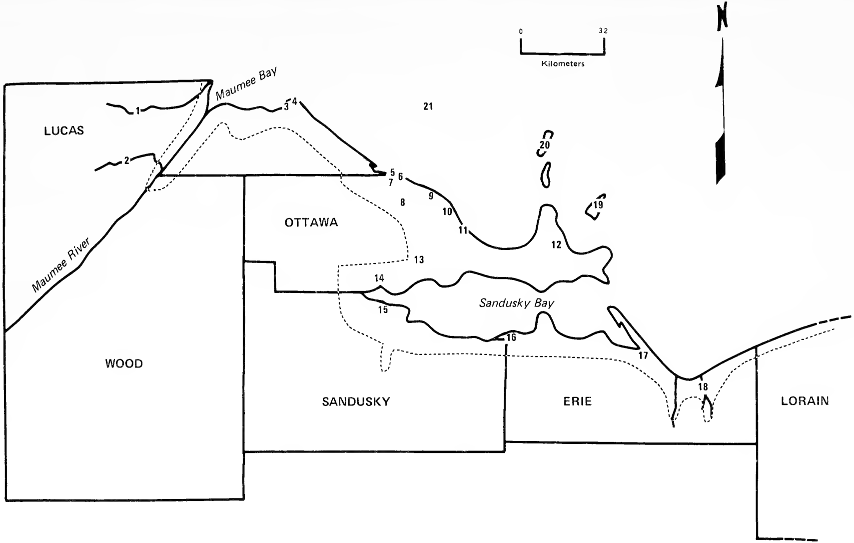

Fig. 4. Collecting sites for melanistic *Thamnophis s. sirtalis*. 1–Wildwood Metropark; 2–Medical College of Ohio; 3–Nile's Woods; 4–Cedar Point NWR; 5–Crane Creek SP; 6–Magee Marsh; 7–Ottawa NWR; 8–Toussaint Creek WA; 9–Navarre Marsh; 10–Camp Perry; 11–Darby Marsh; 12–East Harbor SP; 13–Little Portage River WA; 14–Winous Point; 15–Ottawa Shooting Club; 16–Willow Point WA; 17–Sheldon's Marsh; 18–Old Woman's Creek; 19–Kelleys Island; 20–Middle Bass Island; 21–West Sister Island.

extends little beyond its boundaries. Conant (1938a, 1951) listed only five localities for melanistic *T. sirtalis,* of which we have not been able to verify one of these at the present. To this we have added 17 new localities, of which the Ottawa Shooting Club locality is a new county record.

We are confident that the vast majority of this form's range in Ohio is encompassed within the boundaries of our data points. The populations at localities 1 and 2 may be due to accidental release of individuals from captivity. In east Erie Co., the habitat utilized by this form effectively terminates near the Lorain Co. boundary; hence, Old Woman's Creek is likely the eastern boundary of this phase. In fact, the phenotype is rare in Erie Co. as a whole, all localities there being represented by only a single specimen.

It may be concluded from our data that the melanistic phase of *T. s. sirtalis* has its center of abundance in Ohio in the marshes extending between Cedar Point NWR and Sandusky Bay. South of Sandusky Bay melanistics are much less common (except at Ottawa Shooting Club near the head of the bay) and seem not to exist east of the Old Woman's Creek area. West of Cedar Point NWR a couple of localities exist within Toledo.

The specimen from Old Woman's Creek was not found by us but by manager Gene Wright, and is the only individual of this form to have been observed by him in the area. Similarly, the specimens observed by us from East Harbor SP and Camp Perry were captured by Doug Ceraldi and Barry Muller, respectively.

For the admittedly limited data we have available, our records indicate a sex ratio of 2 males to 3 females for all areas in the marsh zone combined. Our records also indicate a uniform distribution of size classes (classes beginning at 6 in. and increasing in 6-in. intervals) to a size greater than 24 in., after which fewer individuals occur.

Our observations indicate that melanistic *T. sirtalis* are most active between 1000 h and 1400 h during which 68% of our specimens were sighted (65% of striped-phase individuals were found during this time period). During the time of the second peak of activity in striped-phase *sirtalis* (1630 h to 1900 h, 15% of the observations), we recorded 17% of our melanistic individuals, although not enough data are available to indicate an obvious secondary peak. These comparisons indicate no difference in daily activity patterns between the two phenotypes ($X^2 = .205$, df = 1).

It should be noted that our few populational data allow for only the most crude of conclusions and serve only as rough guidelines until more complete studies are conducted.

Over the past several years many of this form's larger populations in Ohio have been decimated by collecting for the pet trade. This snake is a novelty in such areas as Europe and California, and collecting of large numbers of these snakes for shipment to such places is common. Officially protected lands such as the national wildlife refuge units and state-owned wildlife areas have not been spared from these activities and are, instead, often the focus of attention by collectors. This problem of collecting is further exacerbated by the fact that the melanistic phenotype is a recessive character. Yet, official protection of this restricted form has been lacking, due perhaps, in part, to its lack of distinct taxonomic status. Because it is locally endemic, has a recessive color pattern, and has potential utility in the study of certain evolutionary questions, we highly recommend that the melanistic phase of *T. s. sirtalis* be given protection by the state of Ohio from commercial sale and collection.

Storeria dekayi (Brown Snake)

Ottawa River, Toledo, 6-19-80 (2); Cedar Point NWR, 6-3-80 (1), 7-9-80 (1), 7-14-80 (7); Crane Creek SP, 4-4-69 (3), 4-27-69 (2), 5-2-69 (2); Magee Marsh, 5-6-79 (1); Navarre Marsh, 6-25-80 (1), 6-27-80 (2); Bay View Marsh, 7-24-80 (5); Old Woman's Creek, 7-9-80 (3); Kelleys Island; South Bass Island; Middle Bass Island, 7-3-80 (8), 7-25-80 (20); North Bass Island, 7-11-80 (2). *Uncommon*

This species was most abundant in field situations and was most easily found where there was cover under which to look. Both of these factors may account for its rather spotty distribution in the coastal zone. This is one reptile which, within the coastal zone, may be frequently found in woods.

The Kelleys Island and South Bass Island localities are based on the observations of Richard King in 1980.

This species has also been reported from Cedar Point, Castalia, Sandusky, and Huron, Erie Co.; and Port Clinton, Catawba Peninsula, Marblehead Peninsula, and Rattlesnake Island, Ottawa Co. (Conant 1938a) and Gibralter Island (Langlois 1964).

Diadophis punctatus edwardsi (Northern Ringneck Snake)

South Bass Island *Rare*

This species was seen on South Bass Island by Richard King during the summer of 1980.

Also recorded by Conant (1938a) from near Port Clinton and the Catawba and Marblehead Peninsulas.

Heterodon platyrhinos (Eastern Hognose Snake)

Kelleys Island, 7-23-81 (1). *Rare*

A melanistic DOR specimen was found near the quarry on the south side of the island.

It has been reported by Conant (1938a, 1965) from Cedar Point, Kelleys Island, and Sandusky, Erie Co.; and Marblehead Peninsula and South Bass Island, Ottawa Co.

Coluber constrictor flaviventris (Eastern Yellowbelly Racer)

Marblehead Quarries, 8-14-80 (1); Huron River, 8-8-80 (1); South Bass Island; Middle Bass Island, 5-30-81 (1), Kelleys Island. *Rare*

This species is rare in the coastal zone because of its preference for drier, more upland habitats than exist in most of this region. All of our specimens were found in dry, open conditions without nearby wetlands.

The South Bass and Kelleys Island records are based on the observations of Richard King in 1980.

The species has been recorded previously from Cedar Point, Erie Co.; Catawba, Ottawa Co.; and Cedar Point NWR, Lucas Co. by Conant (1938a).

Elaphe vulpina gloydi (Eastern Fox Snake)

Ottawa River, Toledo, 6-19-80 (3); Nile's Woods, 6-18-80 (1); Cedar Point NWR, 6-23-80 (1), 6-30-80 (1), 7-9-80 (8), 7-14-80 (2); Metzger's Marsh, 5-19-81 (1); Ottawa NWR, 6-20-80 (12), 6-24-80 (6), 5-29-81 (8); Crane Creek SP, 6-17-80 (9); Magee Marsh, 6-16-80 (1), 6-18-80 (2); Toussaint Creek WA, 6-27-80 (4), 6-30-80 (5); Toussaint Shooting Club, 7-29-80 (5), 8-3-80 (1); Darby Marsh, 7-1-80 (5); East Harbor SP, 6-26-80 (2), 7-7-80 (2); Marblehead Quarries, (1); Little Portage River WA, 5-27-77 (1), 5-16-80 (2); Winous Point, 7-25-80 (2); Troy Twp., Wood Co., 8-73 (1); Elmore, Ottawa Co., 8-73 (1); Ottawa Shooting Club, 6-6-81 (2); 3 mi E of Green Springs, Seneca Co., 8-30-69 (2), 9-27-69 (2); Willow Point WA, 5-16-81 (3); Castalia, 6-6-81

(1); Bay View Marsh, 7-30-80 (2); Old Woman's Creek, 7-9-80 (2); Kelleys Island, 7-23-81 (2); South Bass Island, 6-14-79 (1); Middle Bass Island, 6-8-80 (1), 7-3-80 (1); North Bass Island, 7-11-80 (2); West Sister Island. *Common*

This species is restricted in Ohio largely to the marsh zone but extends outside of this in the southwest portion of its range. The Old Woman's Creek records extend the known range of this species 6 mi to the east. It probably does not range east much beyond this locality due to the termination of its preferred habitat. Collecting to the east of Old Woman's Creek has failed to yield *E. vulpina.* The locality east of Green Springs, Seneca Co., represents a range extension of 10 mi to the south and a new county record.

The Marblehead locality is based on the observations of Doug Ceraldi, while the West Sister Island locality was recorded by Richard King. All were observed in 1980.

Our data indicate an overall sex ratio of 2 males to 1 female. When juveniles are excluded and the sex ratio examined for each month for which there are adequate data, a slight increase in the proportion of males occurred between May and June, which was maintained through July. This may reflect the less mobile habits of gravid females during this time. Unfortunately, data are unavailable on the sex ratio at birth, so it is unknown if the sex ratio of 2 to 1 was actual or reflects the more sedentary habits of females.

The smallest gravid female collected was 95 mm. This provides an estimate of 36 in. as the size at which sexual maturity can be attained in this species; however, males may achieve sexual maturity before this size is reached (Fitch, 1970). As such, 73% of our specimens were reproductively mature. While this seems to indicate that many of the populations we sampled are reproductively stable, it does not represent an accurate age-class structure for the populations due to the difficulty of locating neonates and juveniles. In only one population were we able to obtain sufficient numbers of neonates and juveniles, and this was due to the fact that artificial cover was available at this locality. This indicates that the neonates and juveniles remain secretive until around the time of reproductive maturity. Conditions of dense vegetation and scarce cover at many of the localities make locating neonates and juveniles very difficult.

There is some indication of a slight sexual size dimorphism, with a greater proportion of males than females larger than 48 in. (one male was over 60 in.), while more of the females occurred in the size class

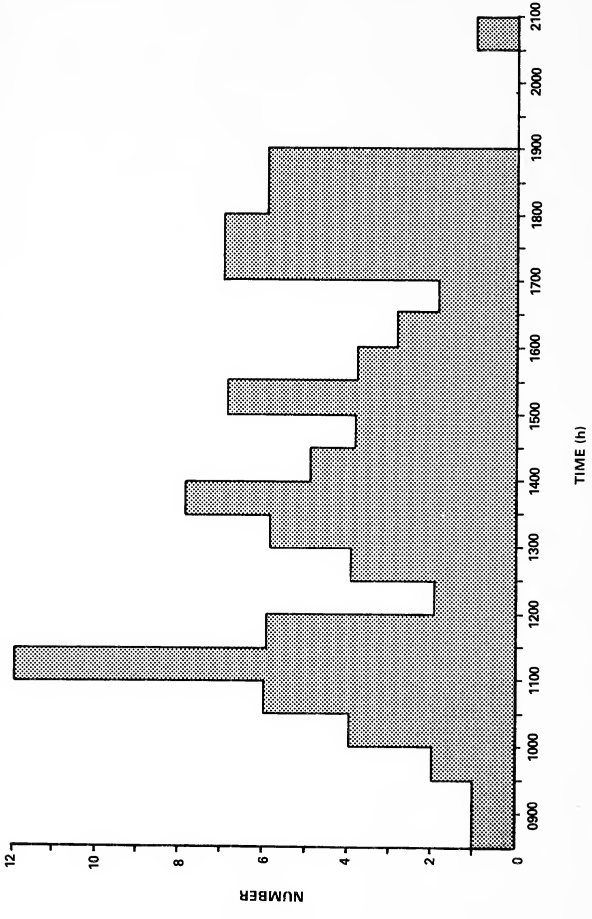

Fig. 5. Observation times of *Elaphe vulpina gloydi.*

37 to 48 in. This size dimorphism (males larger) may indicate that this taxon engages in male-male combat (Shine 1978; see also Gillingham 1980).

Our records indicate that *E. vulpina* was active throughout the day without a noticeable peak of activity (Fig. 5). However, seasonal variation in abundance does occur. This species is most commonly seen from May through June. During July its activity decreases, and in August it is very difficult to find. During August 1980 we saw only two specimens, whereas more than 50 had been seen in the last two weeks of June and 30 in July. This reduction in numbers seen as the summer progresses is similar to that observed by Conant (1938b).

While the fox snake seems to be common in much of its range, it is potentially threatened by capture for commercial sale in much the same way as the melanistic *T. s. sirtalis* discussed previously. Therefore, we support a ban on commercial collecting and sale of this species in Ohio.

Conant (1938a, 1965) lists several other localities for the fox snake in Lucas, Wood, Ottawa, Sandusky, and Erie Cos.

Discussion

In the course of this survey, 28 herpetofaunal species were collected, of which we consider 11 species to form a characteristic marshland assemblage. They are as follows:

Rana catesbeiana
R. clamitans melanota
R. pipiens
Chelydra s. serpentina
Emydoidea blandingi
Chrysemys picta marginata
Nerodia s. sipedon
Regina septemvittata
Thamnophis butleri
T. s. sirtalis
Elaphe v. gloydi

This category is composed of species which are either common in the marsh zone (e.g., *Chrysemys*), are far less common in other habitats in NW Ohio (e.g., *Regina*), or may appear to be uncommon as an artifact of difficulty of observation yet have an extensive range within the marsh zone (e.g., *Chelydra*). The remaining 17 species surveyed are either rare in the marsh zone or prefer non-marsh habitats, such as fields or upland woods, which are of limited distribution in the study area.

Of the 11 species (one with two distinct color phases) considered by us to be characteristic of the marsh zone habitat, 8 are of widespread occurrence in the eastern United States, 2 have their distributions lying largely to the west, one is of restricted occurrence in the midwest, and the melanistic phase of *T. s. sirtalis* is endemic in the marsh zone. Due to the location of the study site, the occurrence of a largely eastern herpetofauna is to be expected. The two western elements (*E. blandingi* and *E. v. gloydi*) and the midwestern form (*T. butleri*) have been hypothesized as extending their ranges to the east with the extension of the Prairie Peninsula during the Xerothermic Interval (Schmidt 1938; see Conant 1978, for an overview). No explanation, to our knowledge, has been offered to account for the persistence of the melanistic phase of *T. s. sirtalis* in the marsh zone, or why it has not increased its geographical distribution. The apparent restriction of this color morph within the marsh zone suggests a high selective pressure favoring the melanistic phenotypes in the marsh zone, or a low-level gene flow across the ecotone (Endler 1977). Because of the ability of *T. s. sirtalis* to establish itself successfully in numerous different habitats, we consider the latter explanation less likely. We have observed that captive neonatal and juvenile melanistic *T. sirtalis* have a marked feeding preference for fish (*Notropis, Poecilia*) and newly metamorphosed anurans (*Bufo americanus*); interestingly, they typically refuse to feed on suitably sized sympatric annelids (*Lumbricus*). Captive adult specimens, however, will readily accept *Lumbricus* as well as fish and anurans. Arnold (1981a,b) has demonstrated a clear example of geographic variation in feeding behavior with a genetic basis in *Thamnophis elegans.* Thus, the restricted distribution of melanistic *T. sirtalis* may be due to food preferences of the young; we emphasize, however, that this speculation is based on our few casual observations of captive specimens.

In addition to the species recorded by us in the coastal zone, 12 other species have been previously recorded by Walker (1946), Conant (1938a, 1951), and Langlois (1964). These are:

Necturus m. maculosus
Hyla c. crucifer
Pseudacris t. triseriata
Sternotherus odoratus
Terrapene c. carolina
Clemmys guttata

Thamnophis sauritus septentrionalis
Opheodrys v. vernalis
Elaphe o. obsoleta
Lampropeltis t. triangulum
Sistrurus c. catenatus
Crotalus horridus

Moreover, Dr. Bob Meeks has seen and collected *S. c. catenatus* (osum 1324) at Winous Point on both north and south sides of Sandusky Bay, although the populations appear to have been extirpated within the past ten years.

Most of the above species are very rare within the coastal zone and most were not found within marsh habitat. The few specimens previously recorded for most of these species are from populations that were probably small and have likely been subsequently extirpated. The amphibian species, however, may be more common but remained unnoticed due to the short temporal span of the study.

As noted by Conant (1938b), we have observed that herpetofaunal activity in the marsh zone decreased as the summer progressed. This was especially notable for the snakes, and was previously mentioned in the fox snake account. This decrease in activity is probably due to higher temperatures and/or drier conditions which prevail during July and August. Hence, certain species may have appeared rarer in the coastal zone than they actually were because the survey was largely conducted in these two months. Similarly, areas surveyed only during this period may have appeared faunistically more depauperate than they actually were.

No similar decrease in amphibian activity was evident, due, in large part, to the fact that summer presents nonoptimal conditions for most species, thereby not allowing for much of a decrease in activity beyond the low level observed. *Rana pipiens* is an exception in that we observed increased activity as the summer progressed.

Juveniles of most of the reptile taxa were rarely observed. We consider this due to their less conspicuous size and more secretive habits, the relative importance of which varies for each species. For this reason, sufficient data for size class comparisons could not be obtained, and recruitment rate for any of the populations is unknown. The only species for which juveniles were readily found was the secretive *Storeria dekayi,* for which the sampling method does not bias the observation of any age-class.

Due to the accelerated alteration of the marsh zone by man in the past several decades, we believe the data presented by Conant (1938a, 1951) and Walker (1946) to be of questionable present utility. For this reason, the primary goal of this report is to provide information on the present-day geographical distribution and status of the populations of amphibians and reptiles within the coastal zone. We have elucidated what we consider to be the characteristic herpetofauna of the marsh zone; other herpetofaunal elements present within this area are of much lesser abundance and/or restricted geographical range. The Lake Erie Islands, albeit included in the coastal zone, have a quite distinct environment from the mainland marsh habitat, and their herpetofauna is not necessarily characterized by the 11 species listed above.

Although large tracts of habitat are protected within the marsh zone, we consider three forms (*E. v. gloydi, T. s. sirtalis*-melanistic, and *N. s. insularum*), all endemic to the study site and adjacent similar areas in Michigan and/or Ontario, Canada, in need of yet further protection to ensure their continuance in the marsh zone herpetofauna in Ohio.

Because several of the species herein considered are common to abundant in the marsh zone, because large tracts of land are protected, and because several ecological and evolutionary questions are amenable to testing in the area, we highly recommend this site for future herpetological research.

Acknowledgments

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We wish to thank Doug Ceraldi, Richard King, Bob Meeks, Barry Muller, and Gene Wright for specimens. Mike Boyland and Lee Herzberger issued permits to survey on Ottawa NWR property. Charlie Holbrook kindly arranged travel to West Sister Island. Dan Rice provided assistance throughout the study. The Department of Biology, University of Toledo, provided some financial assistance for the preparation of the manuscript. James Gillingham kindly critiqued the original manuscript. We dedicate this paper to Roger Conant.

References

Aleksiuk, M., and P. T. Gregory. 1974. Regulation of seasonal mating behavior in *Thamnophis sirtalis parietalis*. Copeia 1974;681–689.

Arnold, S. J. 1981a. Behavioral variation in natural populations. I. Phenotypic, genetic and environmental correlations between chemoreceptive responses to prey in the garter snake, *Thamnophis elegans*. Evolution 35(3):489–509.

———. 1981b. Behavioral variation in natural populations. II. The inheritance of a feeding response in crosses between geographic races of the garter snake, *Thamnophis elegans*. Ibid. 35(3):510–515.

Blanchard, F. N., and F. C. Blanchard. 1941. The inheritance of melanism in the garter snake *Thamnophis sirtalis sirtalis* (Linnaeus), and some evidence of effective autumn mating. Pap. Mich. Acad. Sci., Arts and Letters, 26: 177–192.

Britt, N. W. 1957. Range extension of *Eumeces* (Scincidae) into Sandusky County, Ohio. Ohio J. Sci. 57:90.

Camin, J. H., and P. R. Ehrlich. 1958. Natural selection in water snakes (*Natrix sipedon* L.) on islands in Lake Erie. Evolution 12:504–511.

Camin, J. H., C. A. Triplehorn, and H. Walter. 1954. Some indications of survival value in the type "A" pattern of the island water snakes of Lake Erie. Nat. Hist. Misc., No. 131:1–3.

Collins, J. T., R. Conant, J. E. Huheey, J. L. Knight, E. M. Rundquist, and H. M. Smith. 1982. Standard common and current scientific names for North American amphibians and reptiles. 2nd ed. SSAR Herpetological Circular No. 12.

Conant, R. 1938a. The reptiles of Ohio. Am. Midl. Nat. 20(1):1–200.

———. 1938b. On the seasonal occurrence of reptiles in Lucas County, Ohio. Herpetologica 1:137–144.

———. 1951. The reptiles of Ohio. 2nd ed., Am. Midl. Nat. 33:1–284.

———. 1965. Snakes of record size from Kelleys Island in Lake Erie. J. Ohio Herpetol. Soc. 5(2):54–55.

——— . 1978. Distributional patterns of North American snakes: some examples of the effects of Pleistocene glaciation and subsequent climatic changes. Bull. MD. Herp. Soc. 14(4):241–259.

Conant, R., and W. M. Clay. 1937. A new subspecies of water snake from islands in Lake Erie. Occ. Pap., Mus. Zool., Univ. Mich. 346:1–9.

———. 1963. A reassessment of the taxonomic status of the Lake Erie water snake. Herpetologica 19(3):179–184.

Downs, F. L. 1978. Unisexual *Ambystoma* from the Bass Islands of Lake Erie. Occ. Pap., Mus. Zool., Univ. Mich. 685:1–36.

Endler, J. 1977. Geographic variation, speciation, and clines. Univ. Princeton Press, Princeton, N.J.

Fitch, H. 1970. Reproductive cycles in lizards and snakes. Univ. Kans. Mus. Nat. Hist. Misc. Publ. 52:1–247.

Gillingham, J. C. 1979. Reproductive behavior of the rat snakes of eastern North America, Genus *Elaphe*. Copeia 1979:319–331.

——. 1980. Communication and combat behavior of the black rat snake (*Elaphe obsoleta*). Herpetologica 36:120–127.

Hamilton, W. J., Jr. 1951. Notes on the food and reproduction of the Pelee Island Water Snake, *Natrix sipedon insularum* Conant and Clay. The Canad. Field-Nat. 65:64–65.

Hirschfeld, C. J., and J. T. Collins. 1961. Notes on Ohio herpetology. J. Ohio Herpetol. Soc. 3(1):1–4.

Langlois, T. H. 1964. Amphibians and reptiles of the Erie Island. Ohio J. Sci. 64:11–25.

Morse, M. 1904. Batrachians and reptiles of Ohio. Proc. Ohio St. Acad. Sci., Vol. IV, part 3, Special Pap. no. 9:95–144.

Schmidt, K. P. 1938. Herpetological evidence for the postglacial eastward extension of the steppe in North America. Ecology 19:396–407.

Shine, R. 1978. Sexual size dimorphism and male combat in snakes. Oecologia 33:269–277.

Uzzell, T. M. 1964. Relations of the diploid and triploid species of the *Ambystoma jeffersonianum* complex (Amphibia, Caudata). Copeia 1964: 257–300.

Walker, C. F. 1946. The amphibians of Ohio. Part 1, the frogs and toads (order Salientia). Ohio St. Mus., Sci. Bull. 1(3):5–109.

Addendum

1) *Pseudacris triseriata triseriata* (Western Chorus Frog)

Ottawa NWR, 4-17-82. *Rare*

Several individuals were heard calling in flooded woods. This species is probably widespread in the coastal zone but was unnoticed by us because of its concentration of activity in early spring.

This species has been recorded on Kelleys Island (Hirschfeld and Collins 1961).

2) Nile's Woods is now included in the eastern section of the newly formed Maumee Bay SP.

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BREEDING BIRDS OF OHIO'S LAKE ERIE MARSHES

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Abstract

The bird populations of 24 of Ohio's Lake Erie marshes were surveyed during the period 1 June–12 August 1980. One hundred thirty-eight bird species were encountered, of which 26 are included on the Ohio Department of Natural Resources "Special Species" list. The Great Blue Heron occurred at the greatest number of sites, followed by the Red-winged Blackbird, Mallard, Tree Swallow, Barn Swallow, and Song Sparrow. Eleven wetlands were judged to be especially significant because of their large size and/or habitat quality. With the exception of Mentor Marsh in Lake County, all the highest quality wetlands were located between Toledo and Sandusky Bay. The text briefly describes each wetland and gives the distributional status of each bird species.

Introduction

The most extensive system of wetlands in the Great Lakes Basin occurs on the southwestern flank of Lake Erie. In that area more than 18,000 acres of estuarine, mudflat, swamp, marsh, and shallow open-water ecosystems

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(Cowardin et al. 1979) provide essential habitat for a great diversity of aquatic and semi-aquatic birds. This wetland avifauna provides people living in the Lake Erie Basin with a unique and irreplaceable recreational resource. The purpose of this study was to survey the breeding bird populations of Ohio's coastal zone wetlands. We hope that the data presented here will add to the knowledge of and appreciation for our avian resources, and provide a useful baseline for the game managers and field biologists who will assess Ohio's wetland avifauna in future years.

This report is divided into six parts. In the remainder of this section we review our methods and discuss a few caveats with regard to interpretation of the data. In the following section, the wetlands are described and unusual features noted. The third section, the longest portion of the study, consists of a catalog of the bird species observed during our surveys. A summary table of wetlands-nesting species, acknowledgments, and references, follow.

Of the 24 wetland parcels treated in this paper, seven were of such small size and had such obviously limited appeal to aquatic birds that we visited them only once. Most other parcels were visited two or three times; a few very attractive marshes (e.g., Little Cedar Point, Ottawa Refuge) were the subject of four or more visits. Typically a visit consisted of a slow, thorough walk alongs the edges of each wetland. Where diked access roads permitted we combined walking with automobile travel. The more extensive marshes with poor access by car or walking were surveyed by canoe. We estimate our total time in the field at 700 to 800 man-hours.

On all trips we carried binoculars and a spotting scope with a 20x objective. We also carried a battery-powered tape recorder and a cassette tape of rail, bittern, and marsh wren songs, which we played at intervals whenever we were within hearing distance of a stand of emergent vegetation.

We attempted to enumerate all species seen, despite the obvious errors inherent in such a procedure. Because of the impossibility of detecting all individuals and because of the differential detectabilities of the various species, few numbers are presented here. We do feel that our numerical estimates are valuable for marsh-to-marsh comparisons and as order-of-magnitude abundance indicators. Thus most of our numbers are converted to less precise (but hopefully less misleading) status designations such as "uncommon," "common," etc. (see Part III).

Readers should be aware of another important caveat in interpreting the results. All surveys were done between 1 June and 12 August, 1980. The occurrences and abundances given pertain only to summer 1980, and may not accurately reflect the avifauna of a given parcel in another summer or at another season. This variability in conditions from one year to the next is the

Fig. 1. The senior author and Larry Schlatter emerge from a day at Little Cedar Point Refuge. (Photo: E. Durbin)

result of several potent forces operating in the Lake Erie marshes: (1) ecological succession, which causes shallow water habitats to change gradually to emergent plant communities and ultimately to dry land, (2) variations in the water level of Lake Erie—a particularly potent force in marshes not well-protected by dikes, and (3) changes in the strategies of marsh managers, who regularly drain some impoundments to allow for soil aeration and establishment of annual forbs, and flood others to kill terrestrial vegetation and provide more waterfowl habitat.

In the pages that follow two conventions are adopted. The names of bird species considered rare or endangered in Ohio are given in capital letters wherever mentioned. These species all appear on the Ohio Natural Heritage Program's "Special Animals" list. Asterisks are used following the name of any marsh parcel considered to be of unusual value as a habitat for nesting birds. Also, in order to preserve space, the scientific names of all bird species are given only after the common names on the annotated list beginning on page 66.

Descriptions of the Marshes

The following describes the major wetland parcels near Lake Erie, beginning near Toledo and proceeding eastward. There are 24 parcels in all, of which we judged 11 to be especially significant because of their size and/or quality. These 11 "significant" parcels are indicated by asterisks. Acreages are approximate, and include only marshland unless otherwise indicated.

1. Maumee Bay State Park* (Lucas County); 1200 acres, including uplands. Visited 4, 6, 7, 9, 14 June; 6 Aug.

This area is mostly open field rather than wetlands, although wet spots exist in ditches and between North Curtice and Cousino Roads. There is an extensive sandy beach along the Lake Erie shore. Most of this area will soon be "developed" (i.e., made unsuitable for most birds). This is especially unfortunate since no less than 7 bird species on the Ohio Natural Heritage Program's "Special Animals" list occur there. Included are UPLAND SANDPIPER (probable nester), MARSH HAWK (common migrant and winter visitant and possible nester), SHORT-EARED OWL (status same as marsh hawk, unsuccessful nesting in April 1980), WESTERN MEADOWLARK (nested successfully in 1980, present in other years), BOBOLINK (many pairs), DICKCISSEL (at least 6 males on territory in June 1980), and GRASSHOPPER SPARROW (at least 2 pairs). The field portion of this parcel is probably the best habitat for open country birds in the Toledo area.

2. Little Cedar Point National Wildlife Refuge* (Lucas County); 1500 acres. Visited 7, 14, 20 June; 7, 13 July.

Little Cedar Point (LCP) is the equal of any other parcel as a home for wetland species. All important wetland habitats are represented: swamp forest, open water, mudflat, sand beach, sedge meadow, cattail marsh, etc. Although the variety and quality of habitats are excellent, the acreages of most of them are exceeded elsewhere. Open water a few inches in depth and emergent marshes are the most extensive habitats.

LCP was the only marsh in which we recorded 3 RAIL species. Gallinules and LONG-BILLED MARSH WRENS were abundant at LCP, and the presence of 10 kinds of ducks was also notable. BALD EAGLES have set up residence at LCP within the past year. We saw both members of the pair during our surveys, and have high hopes that a successful nesting will take place in the future.

3. Toledo Trust Swamp (Lucas County); 275 acres. Visited 4, 20 June; 2 Aug.

This rather small area comprises a marsh and swamp forest southeast of LCP Refuge adjacent to the Toledo Water Pumping Station. Birds there consisted of a limited subsample of the more common species at LCP.

4. Metzger Marsh (Lucas County); less than 200 acres. Visited 21 June; 26 July.

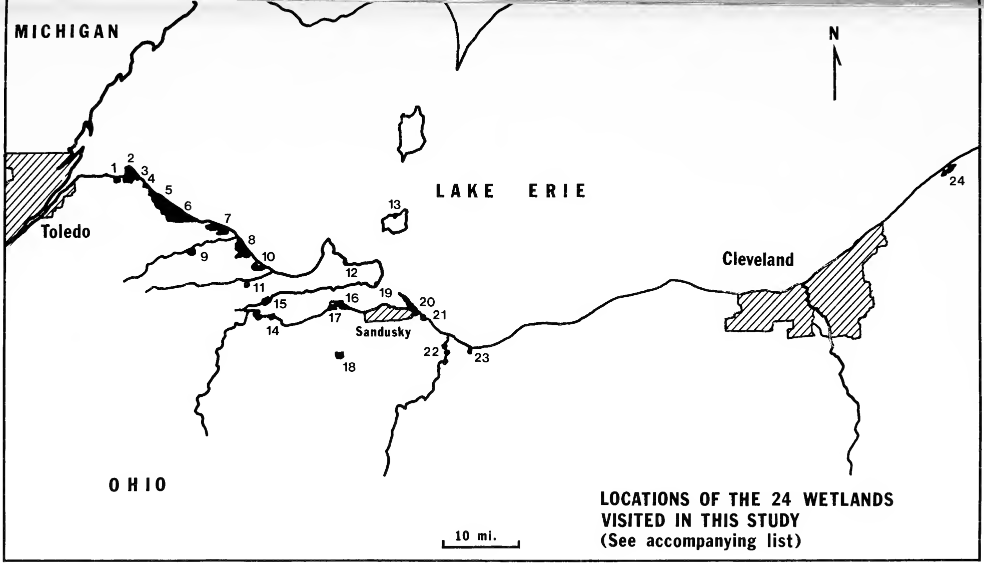

Fig. 2. Wetland parcels surveyed in study. Sites are numbered in geographic order, from west to east. Parcels judged to have outstanding natural value are denoted by asterisks (*). 1. Maumee Bay State Park.* 2. Little Cedar Point National Wildlife Refuge.* 3. Toledo Trust Swamp. 4. Metzger Marsh. 5. Ottawa National Wildlife Refuge.* 6. Magee Marsh complex.* 7. Navarre Marsh.* 8. Toussaint Shooting Club.* 9. Toussaint Creek Wildlife Area. 10. Darby Marsh.* 11. Little Portage River Wildlife Area. 12. East Harbor State Park. 13. Kelleys Island North Pond. 14. Willow Point Wildlife Area. 15. Winous Point Shooting Club.* 16. Bay View marshes.* 17. Moxley's Marsh.* 18. Resthaven. 19. Bay Point Shoal. 20. Wildlife Realty/East Bay marshes. 21. Sheldon's Marsh. 22. Huron River marshes. 23. Old Woman Creek Sanctuary. 24. Mentor Marsh.*

Metzger Marsh is not protected from Lake Erie by dikes, and consequently its water levels conform to those of the lake. North winds are accompanied by strong wave action which causes erosion and the uprooting of cattails. We saw much evidence of this destruction when we explored Metzger by canoe. Open water and broadleaf cattail (*Typha latifolia*) stands are the only habitats. Most of Metzger is too deep for rails and shorebirds.

5. Ottawa National Wildlife Refuge and Crane Creek Experiment Station* (Lucas and Ottawa Counties); 3200 acres. Visited 4, 20, 21 June; 24 July; 2 Aug.

Ottawa forms part of a continuous marsh complex (see No. 6) that is unequaled elsewhere in Ohio and probably in the entire Great Lakes region as a water bird habitat. The refuge includes a series of large diked impoundments. Water levels are regulated by pumping, and vary from one impoundment to the next depending on the management strategies of refuge personnel. In the 1980 nesting season a variety of water levels were available, ranging from wet field and shallow cattail habitats in the northwest sector along Veler Road to open water with fringing mudflats in the eastern portions. Dominant shallow water plants at Ottawa included smartweeds (*Polygonum* spp.), flowering rush (*Butomus umbellatus*), cattails (*Typha* spp.), and various sedges (*Scirpus, Cyperus* and *Carex* species). Several small swamp forest parcels at Ottawa are vitally important for the songbirds and raptors there.

BALD EAGLES nested successfully at the refuge in 1980 (two young were fledged) and the presence of seven species of herons and ten species of ducks was remarkable. Also notable was a successful nesting of WILSON'S PHALAROPE, the first Ohio nesting of this species in this century. Canada Geese were more abundant here and at neighboring Crane Creek Experiment Station than anywhere else in Ohio.

6. Magee Marsh* (Ottawa County); 1850 acres. Visited 10, 11, 21 June; 6 July; 12 Aug.

Magee and Ottawa (No. 5) are more or less continuous, and together form the largest and best marsh parcel in Ohio. Much of what was said about the appearance of Ottawa also holds for Magee, although Magee has little terrestrial habitat and is less varied. Magee had a BLACK TERN colony (missing from Ottawa) but fewer ducks and herons. A unique feature of Magee Marsh was a large central area of damp grassy terrain. This habitat looked suitable for COMMON SNIPE, SHORT-BILLED MARSH WRENS, and possibly the rare BLACK and YELLOW RAILS. However, only the COMMON SNIPE was recorded during our canoe trip around the periphery of this area. The relative inaccessibility of this location and the large number of marshes on our agenda prevented our investigating the center of Magee Marsh at night. Perhaps an entire summer of concerted effort in that one area would yield some records of the rare, elusive small rails.

7. Navarre Marsh* (Ottawa County); 1050 acres. Visited 13, 24 June; 9, 23 July.

Navarre is a collection of diked impoundments located between the community of Sand Beach and the Davis-Besse Nuclear Power Plant. The western-most parcel (behind Sand Beach) is the most attractive habitat for water birds. In 1980 it had a variety of emergent macrophytes interspersed with open water areas. This impoundment supported a nesting colony of BLACK TERNS.

Water levels elsewhere in Navarre were low, however. Cattails grew on exposed mud, and the acreage of cattails was low. Reflecting this lack of cattails, we recorded no RAILS or LONG-BILLED MARSH WRENS at Navarre. Common Gallinules, Great Blue Herons, and GREAT EGRETS were fairly numerous, and we also noted the presence of a thriving colony of CLIFF SWALLOWS (17 nests in 1980) on an old building in nearby Sand Beach.

8. Toussaint Shooting Club* (Ottawa County); 1800 acres. Visited 12, 20 July.

A truly excellent diked wetland at the mouth of Rusha Creek, Toussaint Shooting Club contained large amounts of both marsh and open water habitats. Stretches of cattail were not extensive; much of the emergent vegetation was mallow (*Hibiscus moscheutos*), pickerelweed (*Pontederia cordata*), arrowhead (*Sagittaria* spp.), water lily (*Nymphaea* sp.), and spatterdock (*Nuphar* sp.).

Great Blue Herons, GREAT EGRETS, SORAS, and BLACK TERNS were present in good numbers. One extensive mudflat and several very shallow spots had exceptional migrant shorebird and tern concentrations after early July. Toussaint Shooting Club was our best "find" of the summer. We rate this area as the equal of any other privately owned wetland in the state.

9. Toussaint Creek Wildlife Area (Ottawa County); 175 acres. Visited 10, 12, 17, 20 June.

This is a moderately small area of enclosed marshes on the south shore of the Toussaint River 4.2 mi upstream from Lake Erie. The marsh is dominated by cattails, and there are also some swampy areas with willows (*Salix* spp.) and other woody species. Most of the enclosed marsh is quite shallow; hence ducks and coots are scarce. The habitat appears attractive for RAILS but few were recorded there, perhaps because as a breeding habitat the area is small relative to other parcels nearby.

10. Darby Marsh* (Ottawa County); 550 acres. Visited 19, 30 June; 16 July.

Although we rated Darby as one of the more significant wetlands, a number of other locations were much better. In 1980, at least, Darby fell near the middle of the list of 24 sites as a habitat for wetland birds. Water levels at Darby were relatively low, and the amount of attractive-looking marsh habitat was correspondingly limited. Thus, Darby had a low diversity of ducks and small numbers of herons, especially the GREAT EGRET. RAILS were not encountered. On the other hand, passerines were numerous—especially the Yellow Warbler, which was abundant.

11. Little Portage River Wildlife Area (Ottawa County); c. 200 acres. Visited 8 July.

Virtually dry in 1980. A few Great Blue Herons were seen feeding along one ditch. Deerflies were abundant, but birds scarce. Even Red-winged Blackbirds were absent on our only visit. The area was not worth revisiting.

12. East Harbor State Park (Ottawa County); 1100 acres. Visited 12 June.

The marsh areas within this state park are limited to two large cattail-choked lagoons behind the South Beach lakefront breakwater. Although small, the marsh provides adequate habitat for LONG-BILLED MARSH WRENS, and serves as a feeding ground for the larger waders. The other impoundments within the park are open deep water, with only a fringe of cattails.

13. Kelleys Island North Pond (Erie County); c. 40 acres. Visited 17 July.

This small wet area on otherwise dry and rocky Kelleys Island was disappointing. The margin of the shallow pond is dominated by arrowhead rather than cattail. Only along the south side of the pond is there any really attractive avian habitat. This area of wet meadow and sedge, like many others we found within and along the borders of marsh tracts, seems entirely suitable for the small rails, but none were encountered.

14. Willow Point Wildlife Area (Erie County); c. 90 acres. Visited 8 July.

This area, on the south side of Sandusky Bay, consists of series of small marsh parcels behind dikes. Accessibility is rather poor. Our field notes state: "Good cattails, good mosquitos, good deerflies." Despite the cattails, relatively few aquatic birds were seen at Willow Point.

15. Winous Point Shooting Club* (Ottawa and Sandusky Counties); 2800 acres. Visited 17 June, 24 July.

Winous Point contains excellent aquatic bird habitat, thanks largely to the continual efforts of Dr. Robert Meeks, the Shooting Club's manager, and his staff. The club consists of several large impoundments on both sides of Sandusky Bay. Virtually all types of wetland vegetation are represented within the impoundments, and small acreages of swamp forest are also present.

Birds at Winous Point included 10 species of ducks, 5 of herons, abundant coots and LONG-BILLED MARSH WRENS, BALD EAGLES, many migrating shorebirds, and good numbers of SORA and VIRGINIA RAILS. Two thriving Great Blue Heron nesting colonies are an added attraction.

16. Bay View marshes* (Erie County); 900 acres. Visited 3, 26 July.

These marshes, located east of the town of Bay View, Ohio, are owned for the most part by Medusa Cement Co. They are large and varied, and provide fair to excellent waterbird habitat depending on the parcel. The largest sections are protected from Lake Erie by an elevated railroad bed and a highway. The smaller outer section is exposed to the lake, and wave action takes its toll of the vegetation there during storms and north winds.

VIRGINIA and SORA RAILS were numerous at Bay View, as well as coots and LONG-BILLED MARSH WRENS. The inner marshes supported many herons and migrant shorebirds; the outer marsh was too deep (mostly 9-24 in.) to provide good shorebird habitat. Water levels in the inner marshes were low, and there was much exposed mud and damp grassy flats.

17. Moxley's Marsh* (Erie County); 275 acres. Visited 1, 8 July.

Moxley's, a privately-owned marsh, is protected from Lake Erie by the Bay View marshes and Ohio Route 2. Much of Moxley's was dry during our visits, but the vegetation and cracked mud suggested higher water levels in the recent past. This was an attractive parcel, containing a large heronry at its eastern end and habitat for shore and open country birds as well as aquatic species. LONG-BILLED MARSH WRENS were common, and Moxley's also set our one-day high count for Killdeers: 68 on 1 July.

18. Resthaven (Erie County); 1200 acres. Visited 1 July.

Technically Resthaven is not in the Ohio Coastal Zone, but we include it here because of its reputation as a good bird place and its proximity to parcels 16 and 17.

Unfortunately we found Resthaven to be a relatively poor place for aquatic birds. Most "wet" habitats were series of parallel ditches from which marl had been stripped. Some ditches contained cattails and bulrush (*Scirpus*) while others had been overgrown with woody vegetation. There is good habitat for field and undergrowth species at Resthaven.

19. Bay Point Shoal (Ottawa County); c. 100 acres. Visited 15 July.

Bay Point is opposite Cedar Point at the mouth of Sandusky Bay. Common Terns use it for resting and feeding, but otherwise the shoal is small and attracts relatively few aquatic birds.

20. Wildlife Realty/East Bay marshes (Erie County); 700 acres. Visited 10 July.

The Wildlife Realty marshes, including the East Bay marshes purchased by ODNR, were mostly open water bay with a few arrowhead patches and a very scant fringe of cattails. The area might be good for diving ducks during the migrations, but offers little nesting habitat.

21. Sheldon's Marsh (Erie County); 650 acres. Visited 10, 15 July; 5 Aug.

Sheldon's Marsh is not a marsh, but rather an open lagoon at the mercy of variations in the level of Lake Erie. There were patches of arrowhead here and there, and a cattail fringe grew along the shore in the southwest sector. Habitat for marsh birds was obviously limited. The most attractive features of Sheldon's Marsh were an upland forest and a secluded beach and sand bar, the latter very attractive to gulls and terns.

22. Huron River marshes (Erie County); 150 acres. Visited 31 July, 4 Aug.

The Huron River marshes are a series of rather small, widely separated wetland patches along the Huron River channel south of the city of Huron, Ohio. Most are old river oxbows choked with emergent, broadleaf macrophytes. There were also a few cattail fringes on islands in the Huron River. The only attractive parcel was a small marsh along the railroad tracks 2 mi south of Huron. This marsh, dominated by *Scirpus atrovirens,* grasses, and a few cattails, contained a small number of RAILS.

23. Old Woman Creek Sanctuary (Erie County); 7 acres. Visited 31 July, 4 Aug.

Old Woman Creek Sanctuary is mostly open water and upland forest. Since the lower portion of Old Woman Creek is an estuary, water levels were quite high there in 1980, and habitat for marsh birds was virtually absent.

24. Mentor Marsh* (Lake County); 800 acres. Visited 26, 27 June; 6 Aug.

Mentor is a long, narrow sinuous marsh set between steep forested ridges near Lake Erie. It occupies what appears to be an old channel of the Grand River. The most striking feature of this marsh is the dominance by giant reed (*Phragmites communis*). These reeds and broadleaf cattails form a tall, impenetrable cover over almost the entire wetland. Consequently, Mentor is a very difficult place to see birds. Of all the marshes we visited, only Mentor approximated Brown's (1815) descriptions of the Lake Erie marshes of presettlement days.

The marsh provided good habitat for LEAST BITTERN, VIRGINIA and SORA RAILS, LONG-BILLED MARSH WRENS, and SWAMP SPARROWS. Birds requiring open or deep water habitats were absent. The AMERICAN BITTERN and the Common Gallinule are on the breeding bird list for Mentor Marsh but we did not encounter them during our surveys.

Bird Species Present

During our surveys we recorded 138 species of birds. These are listed below. The order and names used follow the A.O.U. checklist (1957; with addenda by A.O.U. committee on classification and nomenclature 1973, 1976). Each discussion is preceded by a comment on the bird's status in the Lake Erie marshes during June and July of 1980. Status designations may be interpreted as follows:

Abundant: Present in such large numbers that the species would be obvious to even the most casual observer; no particular effort is required to find it. Passerines and other small birds given this status exist in the hundreds or even thousands of individuals in a single marsh; for large birds such as ducks or herons "abundant" indicates over 100 individuals of a species in one parcel .

Common: Present in the appropriate habitat; virtually always found when an effort is made to discover it.

Fairly common: Intermediate in abundance and frequency of occurrence between "common" and "uncommon" species; see following.

Uncommon: Species with this status are seen in a minority of trips to a given locale, either because they are not often present or because they are present in such small numbers that they are frequently overlooked.

Rare: Seen perhaps one or two times in a season; very few individuals present. Very scarce but conspicuous birds such as the Bald Eagle may be given this designation despite their being seen on a high proportion of visits.

The following list contains a number of species that do not nest in the marshes themselves. We included all species that used the marshes or the air over them for feeding, as well as species that occurred in habitats immediately bordering the marsh. The list does *not* include birds we didn't find, even though we may suspect their presence (e.g., American Bittern, Screech Owl).

Fig. 3. Pied-billed grebe at Crane Creek State Park. (Photo: E. Tramer)

GREBES (Order Podicipediformes)

1. Pied-billed Grebe (*Podilymbus podiceps*)–Fairly common breeder in the larger marshes; generally absent from the smaller parcels. Recorded in 9 of the 24 places visited; most numerous at LCP, Magee, and Winous Point.

CORMORANTS (Order Pelecaniformes)

2. DOUBLE-CRESTED CORMORANT (*Phalacrocorax auritus*)–Very rare. One bird seen flying off the beach at East Harbor State Park. Apparently does not breed in Ohio's Lake Erie marshes.

HERONS, EGRETS and BITTERNS (Order Ciconiiformes)

3. Great Blue Heron (*Ardea herodias*)–Common to abundant. This was the only bird encountered in all 24 locations. Great blues used most of the marshes only for feeding. Nesting was restricted to a few large colonies, the most notable being at West Sister Island (8 mi north of Ottawa National Wildlife Refuge in Lake Erie), Moxley's Marsh, and Winous Point. Marshes in which this species was especially abundant

were LCP, Ottawa Refuge, Navarre, Toussaint Shooting Club, and Winous Point.

4. Green Heron (*Butorides striatus*)—Fairly common breeder. Although present in 19 of 24 marshes, this species was not numerous anywhere. Our highest count was 9 individuals at Mentor Marsh.
5. Little Blue Heron (*Florida caerulea*)—Rare summer visitor; probably does not nest in the Lake Erie marshes. Four adult-plumaged birds were feeding at Crane Creek Experiment Station on 2 August. At least one bird was also present through May in Ottawa Refuge.
6. Cattle Egret (*Bubulcus ibis*)—Rare summer resident and probable breeder. Rumored nestings on West Sister Island. We encountered this species three times, once at Ottawa Refuge, once at Magee Marsh, and once in a small pasture south of Locust Point on Route 2—the last record a flock of 40 birds on 31 July.
7. GREAT EGRET (*Casmerodius albus*)—Common summer resident. Most of the great egrets summering in western Ohio nest on West Sister Island. Found in 19 of 24 marshes. This species is virtually absent from eastern Ohio in summer. From the perspective of a resident of northwestern Ohio, this species hardly merits inclusion on the Ohio "Special Species" list. If it is included because of its scarcity elsewhere in the state, all other herons save the Great Blue and the Green should be accorded the same status.
8. Snowy Egret (*Egretta thula*)—Rare summer visitor. We saw one young individual at Winous Point on 24 July. Recently there have been a number of May records of this species at LCP and Ottawa Refuge, and a naturalist at the Crane Creek visitors' center told us that egrets nested on West Sister Island this summer (were these Cattle Egrets?). The nesting status of Cattle and Snowy Egrets in Ohio needs to be investigated.
9. Black-crowned Night Heron (*Nycticorax nycticorax*)—Common summer resident in western Ohio, fairly common to rare east of Port Clinton. Most individuals apparently nest on West Sister Island. This species was most abundant in diked marshes where there were rows of large willows (*Salix nigra*) to roost in. Highest numbers were at LCP, Magee, Navarre, and Toussaint Shooting Club.
10. LEAST BITTERN (*Ixobrychus exilis*)—Uncommon nester in the larger marshes. We encountered this species at LCP and Mentor. Others have recorded it at Ottawa Refuge and Winous Point. No doubt it occurs in small numbers in all the larger marshes where there are extensive cattails.

Fig. 4. The Great Egret is common from Sandusky Bay westward. (Photo: E. Tramer)

GEESE and DUCKS (Order Anseriformes)

11. Canada Goose (*Branta canadensis*)–Assigning an overall status to this species is difficult, if not impossible. It is exceedingly abundant in some places and absent from others. It was encountered in 10 of 24 parcels. Where breeding conditions have been enhanced by nest boxes, artificial islands, etc., the species thrives. Ottawa Refuge and neighboring Crane Creek had the largest populations; the goose was also common at LCP, Navarre, and Darby. It was absent from some of the most attractive marshes, such as Winous Point and Moxley's. This species is quite adaptable and may nest on small ponds and in highly artificial situations. For example, although it was absent from Mentor Marsh proper

we saw Canada Geese on a number of small farm and park ponds in the surrounding countryside.

12. Mallard (*Anas platyrhynchos*)—Common to abundant nester. Easily the most numerous and widely distributed species of waterfowl in the region. Mallards were abundant at LCP, Ottawa Refuge, Magee, and Winous Point.
13. Black Duck (*Anas rubripes*)—Uncommon or rare at LCP, Ottawa, Toussaint Shooting Club, and Winous Point. Not encountered elsewhere.
14. Gadwall (*Anas strepera*)—Rare. Single males were seen at Ottawa Refuge and Bay View marsh. Small numbers have been known to breed in the larger marshes in past years.
15. Pintail (*Anas acuta*)—Uncommon to rare in the larger marshes. We encountered this species in 5 locations. Highest count was 6 at Navarre marsh.
16. Green-winged Teal (*Anas crecca*)—Uncommon to fairly common breeder in the larger marshes. Seen in 7 of the 24 parcels, this species was most numerous in Magee Marsh, where we saw 19 birds on 6 July.
17. Blue-winged Teal (*Anas discors*)—Fairly common in the larger parcels. Nearly 200 of these birds summered in the Ottawa Refuge-Magee Marsh complex. The species was not nearly so numerous elsewhere.
18. American Wigeon (*Anas americana*)—Rare in the larger marshes. A flock of 15 at Ottawa 4 June was apparently a non-breeding aggregation. Otherwise numbers were 6 or less in each parcel. Found in 6 locations.
19. Shoveler (*Anas clypeata*)—Rare and local. Our only record was of two pairs at Magee Marsh. The Shoveler has nested in past years at LCP, Ottawa Refuge, and Winous Point.
20. Wood Duck (*Aix sponsa*)—Fairly common to absent, depending on the location. Recorded in 14 of 24 parcels. The maximum number recorded was more than 100 at LCP on 14 June, but this included a large proportion of young birds. Like most of the waterfowl, this duck preferred the larger marshes.
21. Redhead (*Aythya americana*)—Rare breeder. A pair summered at LCP, and nestings have occurred in past years at Magee Marsh.
22. Ring-necked Duck (*Aythya collaris*)—Possible rare breeder. A non-breeding male summered at Winous Point. In other years pairs have been seen in summer at Ottawa Refuge and LCP.
23. Canvasback (*Aythya valisineria*)—Rare summer visitor; possible breeder. Canvasbacks occasionally appear in the summer in the Lake Erie marshes; we saw a male at LCP on 7 June and another at Ottawa on 21 June.

24. Lesser Scaup (*Aythya affinis*)—Rare summer visitor; very rare breeder. A nonbreeding male was present at Winous Point in 1980. In prior years this species has nested at LCP and possibly elsewhere.
25. Ruddy Duck (*Oxyura jamaicensis*)—Rare summer resident. There are breeding records for Magee Marsh, and our observations of groups of both sexes into July suggest possible breeding of this species in three places in 1980: LCP, Winous Point, and Bay View. We also saw a single male at Toussaint Shooting Club.
26. Hooded Merganser (*Lophodytes cucullatus*)—Rare summer resident. There are nesting records for this species at several locations in Ohio's coastal zone. In 1980 we saw 1 female at Toussaint Creek Wildlife Area 12 June; her secretive actions suggested the possibility of a nearby nest. We also saw 4 birds of this species at Ottawa Refuge on 24 July.

VULTURES, HAWKS, and EAGLES (Order Falconiformes)

27. Turkey Vulture (*Cathartes aura*)—Uncommon visitor. Seen soaring over 7 parcels. All of our observations were in the area from Navarre Marsh eastward to Huron.
28. Red-tailed Hawk (*Buteo jamaicensis*)—Uncommon. Seen in 8 of the 24 marshes. No more than 2 were found at any one location.
29. RED-SHOULDERED HAWK (*Buteo lineatus*)—Rare. A single bird was seen on 4 June at Ottawa Refuge and another on 10 June at Magee. It is possible that these sightings involved the same bird.
30. Broad-winged Hawk (*Buteo platypterus*)—Rare nester. Recorded at Mentor Marsh 27 June. This species is more likely at Mentor than in western Ohio in the summer.
31. BALD EAGLE (*Haliaeetus leucocephalus*)—Rare resident. Present, and relatively conspicuous, at LCP, Ottawa Refuge and Winous Point. We saw at least 8 individuals: one adult and one immature at LCP, 2 adults and 2 nestlings at Ottawa, and one adult and one immature at Winous Point.
32. MARSH HAWK (*Circus cyaneus*)—Very rare nester. Has apparently nested in recent years along Veler Road in Ottawa Refuge. We saw one large brown-plumaged bird (female?) there on 4 June. Nestings are suspected at Maumee Bay State Park and LCP in recent years, but not in 1980.
33. American Kestrel (*Falco sparverius*)—Uncommon at the edges of wetlands. Most often seen where agricultural land abuts the marsh. We found this species at 6 of 24 marshes. Two adults with a recently fledged young were seen at Navarre.

GAME BIRDS (Order Galliformes)

34. Ring-necked Pheasant (*Phasianus colchicus*)–Uncommon. We expected to encounter this species frequently, but it occurred in only 4 places: Maumee Bay State Park, LCP, Ottawa Refuge, and Winous Point. Pheasants are rather secretive in summer, but considering the small number of sightings and hundreds of hours spent afield, we judge this species to be scarce at the present time.

RAILS, GALLINULES, and COOTS (Order Gruiformes)

Rails are among the most difficult birds to census because of their secretive habits and the difficulty of traversing their preferred haunts. We attempted to detect the presence of rails by canoeing or wading along the edge of tracts of emergent vegetation while we played tape recordings of their songs. We also played tapes at night in some of the "best-looking" rail habitats, since these birds are reputed to call more readily in the dark. During June we experienced almost total failure. Our tapes were greeted with silence by the rails, although other species (coots, marsh wrens, etc.) were often stimulated to answer the rail tapes with their own vocalizations.

At Mentor Marsh in late June we were finally successful–a number of Virginia Rails answered. Upon our return to western Ohio we discovered the Virginia Rails there had suddenly "found" their voices as well. On 12 July at Toussaint Shooting Club we succeeded in getting responses from Soras, and from then on both Virginia and Sora Rails were relatively easy to find, even in marshes where no rails had answered in June. We conclude that rails are quite secretive while incubating eggs, and perhaps also while their young are very small. We saw a number of juvenile Virginias and Soras, all nearly adult size, at the time that both species began responding to the tapes.

We also became rather proficient at recognizing "good" rail habitat: tall emergent vegetation (not necessarily cattails) in very shallow water (1–4 in.) is the best. Other bits of information are as follows: (1) Virginia Rails will respond to King Rail calls as well as their own; (2) Soras respond only to Soras and not to other rails, but they are much more likely than Virginias to answer a sudden handclap or a stone thrown into the marsh; and (3) Soras and Virginias are ecologically compatible. Clumps of vegetation where one species was numerous usually harbored many of the other species as well. They often came out to the edge of the vegetation in response to the tapes and fed peaceably within a few feet of one another.

Fig. 5. Nest and eggs of an American Coot in Little Cedar Point National Wildlife Refuge. (Photo: E. Durbin)

35. KING RAIL (*Rallus elegans*)–Rare summer resident and presumed breeder. Heard in cattails near the west gate at LCP on 4 July; seen by other observers near the LCP east gate as well. We lured another bird into the open at Magee Marsh on 6 July; it fed briefly at the edge of some cattails near 2 Virginia Rails. Andrews (1973) found King Rails to be at least as common as Virginias and Soras at Winous Point in 1970–

71. Perhaps subsequent high lake levels, which destroyed most of Winous Point's marshes in 1972-73, reduced the King Rail population to a low level from which it has not yet recovered.

36. VIRGINIA RAIL (*Rallus limicola*)–Fairly common nester in the larger marshes. We saw many young birds in July. Virginias were detected in 9 of 24 parcels. Highest count was 12 at Bay View Marsh. Also numerous at LCP and Mentor.

37. SORA (*Porzana carolina*)–Fairly common nester in the larger marshes. Recorded in 8 parcels; young were seen on two occasions. Highest count was 13 at Bay View Marsh. Also numerous at Toussaint Shooting Club and Winous Point.

38. Common Gallinule (*Gallinula chloropus*)–Fairly common in the larger marshes; young birds were seen on several occasions. We recorded this species in 9 parcels. Gallinules were most abundant by far at LCP, where we saw more than 40 adults on 14 June. Also fairly numerous at Navarre, but strangely absent from the adjacent Toussaint Shooting Club. Our findings of relative abundance were similar to those of Brackney (1979).

39. American Coot (*Fulica americana*)–Fairly common to common nester in the larger marshes; seen in 12 parcels. Several nests were found and nest success was apparently quite high. For example, we saw at least 20 young at Magee on 6 July and more than 40 at Winous Point 24 July. In the Ottawa Refuge-Magee Marsh complex this species was concentrated in the area around the road out to Crane Creek beach; the reason for this pattern was not known.

SHOREBIRDS, GULLS, and TERNS (Order Charadriiformes)

Except for nesting Killdeers and Spotted Sandpipers, shorebirds were scarce until 3 July. Thereafter migrant species became increasingly numerous. Despite the fact that only 5 or 6 species of shorebirds nest in the Lake Erie marshes, their migratory habits make shorebirds an important component of our summer avifauna. Thus we include them here.

40. Semipalmated Plover (*Charadrius semipalmatus*)–Uncommon July visitor; becomes fairly common in August. Almost entirely restricted to mudflats. Encountered in 5 parcels, but no doubt occurs in all parcels where extensive mudflat exists.

41. Killdeer (*Charadrius vociferus*)–Conspicuous breeder in the vast majority of the parcels. Highest count was at Moxley's Marsh.

42. Golden Plover (*Pluvialis dominica*)–Very rare in June and July; an early

fall transient was seen with a large group of shorebirds on 20 July at Toussaint Shooting Club.

43. UPLAND SANDPIPER (*Bartramia longicauda*)–Probably absent from the marshes proper. A rare summer resident in extensive open fields. Habitat for this species exists at Maumee Bay State Park, where this species was seen several times in June 1980, and Ottawa Refuge, where the species has nested in prior years.
44. Greater Yellowlegs (*Tringa melanoleuca*)–Uncommon July transient; increases in abundance in August. Seen in 4 parcels, but more widespread later on.
45. Lesser Yellowlegs (*Tringa flavipes*)–Common transient beginning in early July. Seen in 9 parcels and probably occurs in nearly all of them on migration.
46. SOLITARY SANDPIPER (*Tringa solitaria*)–Fairly common fall migrant beginning in mid-July. Recorded in only 4 parcels, but regularly seen in most of the others by ourselves and other bird watchers during spring and fall migration.
47. Spotted Sandpiper (*Actitis macularia*)–Common nester along the edges of most of the larger marshes. Recorded in 13 parcels; highest count was 30 at Toussaint Shooting Club.
48. Ruddy Turnstone (*Arenaria interpres*)–Rare migrant. A late-migrating flock of 9 was seen on the beach at LCP on 7 June.
49. WILSON'S PHALAROPE (*Steganopus tricolor*)–Uncommon transient; normally not encountered in June or early July, but in 1980 a pair nested successfully at Ottawa Refuge. As best we can determine, this is the first attempted nesting in Ohio in this century. Personnel from Crane Creek Experiment Station discovered a nest containing 4 eggs on 4 June. At least two chicks hatched; these were banded and photographed on 22 June (Shieldcastle 1980). We observed the adult pair of phalaropes preening and feeding together on 21 June and 2 August.
50. American Woodcock (*Philohela minor*)–Probably a fairly common nesting species where thickets or swamp forests abut the edges of marshes. A regular breeder at Ottawa Refuge, LCP, Mentor, and probably elsewhere. We encountered an injured bird on Veler Road in Ottawa Refuge on 4 June, and saw several at Sheldon's Marsh and near Wildlife Realty marshes in the Cedar Point area.
51. COMMON SNIPE (*Capella gallinago*)–Local and uncommon summer resident. Although we found no nests or young, the presence of adults in at least 4 parcels during the summer leads us to designate the snipe as a nesting species. Seen at Ottawa Refuge, Magee Marsh, Toussaint

Fig. 6. Dowitchers and unidentified small sandpipers in silhouette at Ottawa National Wildlife Refuge. (Photo: C. Manzey)

Shooting Club, and Bay View marshes. All sightings were in open wet areas with low vegetation.

52. Short-billed Dowitcher (*Limnodromus griseus*)—Locally common July transient; seen in 5 parcels. Especially numerous this summer in Toussaint Shooting Club.
53. Semipalmated Sandpiper (*Calidris pusilla*)—Fairly common transient in July; becomes common to abundant later. Seen in 4 parcels, but by mid-August it undoubtedly occurs in all marshes.
54. Least Sandpiper (*Calidris minutilla*)—Common transient in July; seen in the same 6 parcels as the Pectoral. No doubt it occurs in all of them.
55. Pectoral Sandpiper (*Calidris melanotos*)—Fairly common July transient; seen in 6 of the larger marshes.
56. Dunlin (*Calidris alpina*)—Rare migrant in June and July; a common to abundant migrant in May and September-October. June and July birds, seen in three parcels, included two obviously crippled individuals.
57. Stilt Sandpiper (*Micropalama himantopus*)—Uncommon fall transient. In July 1980 small flocks of this species were encountered at Ottawa Refuge, Navarre Marsh, and Winous Point.
58. Great Black-backed Gull (*Larus marinus*)—Rare summer visitor. An individual of this species in immature plumage was seen with a large

flock of Herring gulls at Sheldon's marsh on 10 July.

59. Herring Gull (*Larus argentatus*)—Common summer visitor. Seen in 17 of 24 parcels. Peak number was about 250 at both Toussaint Shooting Club and Sheldon's marsh. This species apparently nests on islands in the Lake.
60. Ring-billed Gull (*Larus delawarensis*)—This species was somewhat less numerous and less widespread than the Herring gull. We encountered it in 12 parcels.
61. Forster's Tern (*Sterna forsteri*)—Uncommon to rare July transient. We identified this species in only two places, but expect that it is more common and widespread in August and September.
62. COMMON TERN (*Sterna hirundo*)—Fairly common visitor to some of the larger marshes. Numbers increase in late July as adults and young leave their nesting colonies and congregate on mudflats in the marshes. Nesting areas are not located in the marshes; the species apparently uses islands and dredge spoils in Lake Erie proper. Seen in 6 parcels.
63. Caspian Tern (*Sterna caspia*)—Uncommon summer transient. We saw 1 or 2 individuals of this species at LCP throughout June. There are no nesting records for Ohio, however. In July we also saw this species at Toussaint Shooting Club, Bay View, and Sheldon's marsh.
64. BLACK TERN (*Chlidonias niger*)—Fairly common but local nester in the larger marshes. Seen in 8 parcels; definite nesting observations at LCP, Navarre, Magee, and Toussaint Shooting Club.

PIGEONS and DOVES (Order Columbiformes)

65. Rock Dove (*Columba livia*)—Seen in 7 parcels, but usually just flying low overhead. No doubt this species rarely, if ever, uses the marshes for feeding.
66. Mourning Dove (*Zenaida macroura*)—Common to fairly common resident at the fringes of the marshes. Seen in 17 of 24 locations.

CUCKOOS (Order Cucliformes)

67. Yellow-billed Cuckoo (*Coccyzus americanus*)— Fairly common breeder in dense vegetation around the edges of dikes, swampy areas, etc. Seen in 12 parcels.
68. Black-billed Cuckoo (*Coccyzus erythropthalmus*)—Uncommon breeder in the same habitats as the preceding species. Encountered in 7 parcels. This and the preceding species occurred in only 2 locations in common, suggesting either slightly different requirements or competitive exclusion between the 2 cuckoos.

Fig. 7. Nest and eggs of a Black Tern in Little Cedar Point National Wildlife Refuge. (Photo: E. Durbin)

OWLS (Order Strigiformes)

69. Great Horned Owl (*Bubo virginianus*)—Fairly common resident in marshes fringed with large trees. Encountered in only 4 parcels, but known to occur in virtually all of them.
70. Barred Owl (*Strix varia*)—Rare except at Mentor, where this species is the commonest large owl.

SWIFTS and HUMMINGBIRDS (Order Apodiformes)

71. Chimney Swift (*Chaetura pelagica*)—Feeds regularly over all the marshes; nests in nearby chimneys, etc.
72. Ruby-throated Hummingbird (*Archilochus colubris*)—Uncommon breeder. Seen at LCP, Magee, Navarre, and Huron River.

KINGFISHERS (Order Coraciiformes)

73. Belted Kingfisher (*Megaceryle alcyon*)—Fairly common from Navarre eastward; not encountered at Magee, Ottawa Refuge, or any of the Lucas County sites. Perhaps the extremely flat topography of northwest Ohio offers few nesting banks for this species.

WOODPECKERS (Order Piciformes)

74. Common Flicker (*Colaptes auratus*)—Fairly common to common breeder on the edges of most of the marshes.
75. Red-bellied Woodpecker (*Melanerpes carolinus*)—Rare. Seen only at Mentor; has nested in the past at Ottawa Refuge.
76. Red-headed Woodpecker (*Melanerpes erythrocephalus*)—Uncommon in marshes with standing dead timber.
77. Downy Woodpecker (*Picoides pubescens*)—Fairly common on marsh fringes. Recorded at 7 locations.
78. Hairy Woodpecker (*Picoides villosus*)—Rare. This species prefers large stretches of woods; we saw it only at Mentor where extensive beech-maple forest surrounds the marsh.

PERCHING BIRDS (Order Passeriformes)

79. Eastern Kingbird (*Tyrannus tyrannus*)—Common and widely distributed (in 18 parcels). This species often nests in very exposed locations; we saw several nests in dead trees in the open marsh.
80. Great Crested Flycatcher (*Myiarchus crinitus*)—Uncommon in swampy areas. Seen on the edges of 6 marshes.
81. Eastern Phoebe (*Sayornis phoebe*)—Rare. We saw a single bird in the Huron River marshes. This species frequently occurs in July and August on the Crane Creek State Park "Bird Trail," suggesting a nearby breeding site.
82. Willow Flycatcher (*Empidonax traillii*)—Common nester in willows, dogwoods, and other shrubs along the edges of most of the marshes. Seen in 15 parcels.
83. Eastern Pewee (*Contopus virens*)—Uncommon. A woodland bird that infrequently uses the marshes proper.

84. Horned Lark (*Eremophila alpestris*)—Rare visitor to the marshes in western Ohio. A common nester in nearby fields.
85. Tree Swallow (*Iridoprocne bicolor*)—Common to abundant in virtually all marshes. Numbers were highest in marshes with standing dead trees that provided nesting cavities.
86. Bank Swallow (*Riparia riparia*)—Abundant late summer migrant through the marshes; apparently does not nest in them.
87. Rough-winged Swallow (*Stelgidopteryx serripennis*)—Uncommon summer visitor and migrant. Nests outside the marshes in creek valleys and road cuts, etc.
88. Barn Swallow (*Hirundo rustica*)—Common summer visitor; nests on buildings and bridges nearby.
89. CLIFF SWALLOW (*Petrochelidon pyrrhonota*)—Rare visitor and migrant; nests at Sand Beach near Navarre Marsh.
90. Purple Martin (*Progne subis*)—Common summer visitor; nests nearby in man-provided structures. A few birds may actually nest in natural tree hollows in the marshes.
91. Blue Jay (*Cyanocitta cristata*)—Uncommon visitor to most of the marshes; common in uplands nearby.
92. Common Crow (*Corbus brachyrhynchos*)—Status same as Blue Jay.
93. Black-capped Chickadee (*Parus atricapillus*)—Generally absent from the marshes. Common resident in the woods surrounding Mentor Marsh.
94. Tufted Titmouse (*Parus bicolor*)—Uncommon visitor to the marshes proper; a common resident in upland woods.
95. White-breasted Nuthatch (*Sitta carolinensis*)—Status similar to the chickadee.
96. BROWN CREEPER (*Certhia americana*)—Rare. We saw a pair in standing dead and dying timber in Mentor Marsh. The behavior of these birds suggested a nearby nest.
97. House Wren (*Troglodytes aedon*)—Common and widespread nester in marshes with dead stubs and wet thickets; in 16 of 24 parcels.
98. LONG-BILLED MARSH WREN (*Cistothorus palustris*)—Locally common. Apparently restricted to marshes with tall cattails. Present in 13 parcels. Highest counts were at LCP, Magee, Metzger, Winous Point, and Bay View.
99. SHORT-BILLED MARSH WREN (*Cistothorus platensis*)—Rare. Our only record was an individual singing in atypical vegetation (cattails) in LCP on 14 June. Good habitat for this species is lacking in most of the marshes; the best-looking habitat we saw was in Magee Marsh.

100. Gray Catbird (*Dumetella carolinensis*)—Fairly common in thickets along the borders of marshes. Seen in 12 parcels.
101. Brown Thrasher (*Toxostoma rufum*)—Uncommon in thickets along marsh borders; in 9 parcels.
102. Robin (*Turdus migratorius*)—Common nester along wooded marsh borders. Often seen feeding far from trees on dikes.
103. Wood Thrush (*Hylocichla mustelina*)—Absent from the marshes proper; seen or heard in wooded areas adjacent to 5 of the parcels.
104. Blue-gray Gnatcatcher (*Polioptila caerulea*)—Rare breeder in swamp forests. Recorded at Winous Point and Mentor.
105. Cedar Waxwing (*Bombycilla cedrorum*)—Fairly common in wet forests and bushy areas along dikes, etc. No doubt nests in dense shrubs and low trees fringing many of the marshes.
106. Starling (*Sturnus vulgaris*)—Fairly common visitor; nested in small numbers where there was standing dead timber.
107. White-eyed Vireo (*Vireo griseus*)—A rare species of dense thickets. We heard a White-eyed singing at Resthaven.
108. Yellow-throated Vireo (*Vireo flavifrons*)—Absent from the marshes proper. Males of this species were singing in the forest adjoining Mentor Marsh.
109. Red-eyed Vireo (*Vireo olivaceus*)—Fairly common in wooded areas near the marshes; recorded adjacent to 9 parcels.
110. Warbling Vireo (*Vireo gilvus*)—Common nester in tall trees in marshes and along marsh borders. Recorded in 13 marshes.
111. PROTHONOTARY WARBLER (*Protonotaria citrea*)—Rare and local nester in swampy portions of marshes. We found this striking warbler at Crane Creek Bird Trail, Navarre, Toussaint Shooting Club, and Darby Marsh.
112. Yellow Warbler (*Dendroica petechia*)—Common to abundant nester in virtually all of the marshes. Highest densities were at Ottawa Refuge, Navarre, Darby, and Winous Point.
113. Yellowthroat (*Geothlypis trichas*)—Common and widespread nester. Recorded in 18 parcels, but nowhere as numerous as the preceding species. Highest densities were at Resthaven and Mentor.
114. Yellow-breasted Chat (*Icteria virens*)—Absent from most marshes; recorded in wet thickets at Navarre, Toussaint Shooting Club, and Darby Marsh. More common in dense upland habitats.
115. Hooded Warbler (*Wilsonia citrina*)—A bird of rich upland forests that rarely occurs in swampy areas near the marshes. A male of this species spent the summer in a small swampy woods at Navarre Marsh. The

species nests in the forests surrounding Mentor.

116. American Redstart (*Setophaga ruticilla*)–Another upland forest bird that rarely visits swampy woods near the marshes. We heard males singing in June in wet woods at Ottawa Refuge and Magee Marsh.
117. House Sparrow (*Passer domesticus*)–Uncommon visitor to the marshes, mostly along dry dikes or near buildings, as at Winous Point.
118. BOBOLINK (*Dolichonyx oryzivorus*)–An uncommon summer visitor to the marshes; nests in extensive fields adjacent to several of the wetlands. Seen at Maumee Bay State Park (nesting), Ottawa Refuge (nesting), Magee Marsh (transients), Toussaint Creek Wildlife Area (lone territorial male), and Moxley's (a flock of transients feeding on the dike).
119. Eastern Meadowlark (*Sturnella magna*)–Rare in the marshes; seen only at Moxley's, although meadowlarks were uncommon nesters in fields adjacent to a number of other parcels.
120. WESTERN MEADOWLARK (*Sturnella neglecta*)–Nested successfully at Maumee Bay State Park in a large field. An adult was seen feeding a fledgling on two occasions in July.
121. Red-winged Blackbird (*Agelaius pheoniceus*)–Common to abundant; widespread.
122. Orchard Oriole (*Icterus spurius*)–Rare summer resident and probable rare nester in edges adjacent to marshes. Encountered at Winous Point and on Kelleys Island.
123. Northern Oriole (*Icterus galbula*)–Fairly common nester in trees lining dikes, etc. Seen in 14 parcels.
124. Common Grackle (*Quiscalus quiscula*)–Common visitor to marshes and marsh edges; nested where swampy forests existed near the marshes.
125. Brown-headed Cowbird (*Molothrus ater*)–Fairly common visitor to the edges of marshes; seen in 10 parcels. A frequent brood parasite of the Yellow Warbler and other small open-nesting species.
126. Cardinal (*Cardinalis cardinalis*)–Common nester in thickets and wooded areas bordering the marshes.
127. Rose-breasted Grosbeak (*Pheucticus ludovicianus*)–A moist forest species. Rare breeder in the vicinity of the marshes, except for Resthaven and Mentor, where it is fairly common.
128. Indigo Bunting (*Passerina cyanea*)–Common to abundant in edge and thicket habitats bordering virtually all the marshes.
129. DICKCISSEL (*Spiza americana*)–Rare. Loose colonies of territorial males summered in fields at Maumee Bay State Park and in Ottawa Refuge. Successful breeding was documented at the state park.

130. American Goldfinch (*Carduelis tristis*)–Common to abundant breeder on overgrown dikes and in fields adjoining marshes.
131. Rufous-sided Towhee (*Pipilo erythrophthalmus*)–Uncommon to rare breeder in woods and thickets; not a bird of the marshes proper. Encountered only in central and eastern Ohio.
132. Savannah Sparrow (*Passerculus sandvichensis*)–Uncommon visitor; probable rare nester on grassy dikes within a few of the marshes but much more likely on upland fields nearby.
133. GRASSHOPPER SPARROW (*Ammodramus savannarum*)–Absent from the marshes. At least 2 pairs summered at Maumee Bay State Park in a large open field with very low vegetation.
134. HENSLOW'S SPARROW (*Ammodramus henslowii*)–Rare. Nested in a large wet field adjacent to marshes on Veler Road in Ottawa Refuge.
135. Chipping Sparrow (*Spizella passerina*)–An upland species that occasionally fed on dikes or other dry open areas adjacent to the marshes.
136. Field Sparrow (*Spizella pusilla*)–Status same as the Chipping Sparrow.
137. SWAMP SPARROW (*Melospiza georgiana*)–Absent from most of the marshes; a rare nester in 3 western parcels, fairly common in 3 easterly ones. We were astonished at the scarcity of this species as a breeding bird. It nested in abundance at Irwin Prairie (an inland marsh west of Toledo), and migrates and winters commonly in most of the marshes in the state. The reasons for its virtual absence from the western Lake Erie marshes in summer 1980 are not known.
138. Song Sparrow (*Melospiza melodia*)–Common in virtually all of the parcels. Restricted to marsh edges and places in the marshes where heavily vegetated soil protrudes above the water surface.

TABLE 1

Summary of wetlands-nesting species by parcel.

	Parcel																							
Species	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*
Pied-billed Grebe		F			F	F	F		F	U					F	U	U							
Great Blue Heron	U	A	F	F	A	C	A	A	F	A	F	C	U	U	A	C	C	U	U	U	F	U	R	R
Green Heron		U	U	U	U	U	F	U	F	U	U	U			F	F	R	U	U		R	U		F
Great Egret	U	A	F	F	C	C	C	A	F	F	U	F		U	F	C	F	F			R	U		
Black-cr. Night Heron		C	F	F	F	C	C	A	C	C		U	U	U	U	C	U			R		U		
Least Bittern		U																						U
Canada Goose		C			A	C	C	U	C	F		F				U	R							
Mallard	F	A	F	U	A	A	C	A	U	A		F		U	A	C	F	U	F		U	F	R	F
Black Duck		U			R			R							R									
Gadwall					R											R								
Pintail	U	R			U		U								R									
Green-winged Teal		U			U	F	U			U					U	U								
Blue-winged Teal	F	C			C	C	F	C		F					C	U								
American Widgeon		R			R	R	R	R							R									
Shoveller					U	U																		
Wood Duck		A			F	F	C	F	C	F					U	U	U	F		F			R	F
Ruddy Duck		R						R							U	R								
Hooded Merganser					R				R															
Bald Eagle		R			R										R									
Marsh Hawk					R																			

Migrants, non-nesting incidental visitors, and species of adjacent terrestrial habitats are excluded. Status designations: A–abundant, C–common, F–fairly common, U–uncommon, R–rare. Parcel numbers refer to the list on page 59.

TABLE 1 (*continued*)

Species	*Parcel*																							
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*
King Rail		R				R																		
Virginia Rail		U			R	U		U							U	F	U					R		U
Sora		U		U				U	R						U	F						R		R
Common Gallinule		C			U	U	F		R	U		R			U	U								
American Coot		C		F	F	A	F	U	R	F					C	C	F			U				
Killdeer	U	F		R	C	C	F	C	U	C	U	U		U	C	C	C	U			U			
Common Snipe					R	U		R								R								
American Woodcock					R															R	U			
Spotted Sandpiper	U	F			F	F	U	F		F					F	F	F		F		F	R		
Wilson's Phalarope					R																			
Herring Gull	U	A		U	F	U	F	C	U	C		C			F	C	C		U	U	A	R		
Ring-billed Gull	U	C		U	F		F	C		C		C				U	F			U	U			
Common Tern		F				R		F									R		F		U			
Black Tern		F			R	F	F	C								R	R				U			
Belted Kingfisher							F	U		R			R	U		U	R	R						R
Red-headed Woodpecker		U			R			U				U					R				R	R		F
Eastern Kingbird	U	U			F	U	F	F	U	U		U	U		F	R	U	F	U		U	U		U
Eastern Phoebe					?																	R		
Willow Flycatcher	U	U			F	U	R		U	F	U		U		F	R	U	R			U			F

Tree Swallow	F	C	F		A	A	C	C	A	A		C	C	C	A	A	C	F	F	C	U	U		F
Barn Swallow	F	F	F	U	C	C	F	F	C	C		C	C	C	A	U	U	U		F	U		U	U
Purple Martin		F			C	A	A	C	U	U		C	C	C	A	C	U		F	F	U	F	U	C
Long-billed Marsh Wren		C		C	U	C		F				F		R	C	C	F			U		U		F
Red-winged Blackbird	A	A	C	F	A	A	A	A	A	A		A	C	C	A	A	A	A	C		C	F	F	A
Warbling Vireo		F			F	R	F	U	U	U				U	U		U	F			F			R
Prothonotary Warbler					R		R	R		R														
Yellow Warbler		C	F		A	A	A	F	C	A	U	C	C	U	A	U	U	U				U		F
Yellowthroat	U	U			C	F	F	F	U	C	U	F		U	F	U	F	F			U	F		C
Swamp Sparrow		R			R	R									U			F				F		F
Song Sparrow	A	C			C	A	C	A	U	A		C	C	F	A	F	A	C	F	U	U	C	U	A

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References

American Ornithologists' Union. 1957. Checklist of North American birds. Baltimore, Md. 5th ed.

American Ornithologists' Union Committee on Classification and Nomenclature. 1973, 1976. Auk 90: 411-419 and Auk 93: 875-879.

Andrews, D. A. 1973. Habitat utilization by Sora, Virginia and King rails near southwestern Lake Erie. M.S. thesis, Ohio State University, Columbus.

Brackney, A.W. 1979. Population ecology of Common Gallinules in the southwestern Lake Erie marshes. M.S. thesis, Ohio State University, Columbus.

Brown, S. 1815. Views of the campaigns of the North-Western Army, etc. Wm. G. Murphey, Philadelphia.

Campbell, L. 1968. Birds of the Toledo area. *The Blade,* Toledo, Ohio.

Cowardin, L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Dept. Interior, Fish and Wildlife Service #FWS/OBS-79/31, Washington, D.C.

Shieldcastle, M. 1980. First state nesting record, Wilson's Phalarope (*Steganopus tricolor*). The Ohio Cardinal 3(2):1-2.

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PRELIMINARY REPORT ON SOME PLANTS FROM THE CLEVELAND SHALE

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Abstract

This report gives for the first time descriptions of plants of the Cleveland Shale. Ten different specimens found as compressions or petrifactions in the shale are described. Six are assigned to the group Lycopsida, three are unassigned, and one is probably a progymnosperm. Surprisingly, of the six lycopsids, four are represented by large, well-preserved cones.

Introduction

The Cleveland Shale, of Upper Devonian Age (Banks and Feldmann 1970), outcrops mainly to the west and the southwest of Cleveland, Ohio. This marine shale is black to greyish black in color and is nicely exposed in Big Creek and on the banks of the Rocky River (Fig. 1).

The story of the shale goes back to 1866 when for the first time it caught the attention of Rev. H. Hertzer who first collected fossil fish from it. Hertzer found evidence of many large and strange creatures with heavily armored heads and jawbones that were in such abundance here and elsewhere that the Devonian has been called the "Age of Fishes" (Hyde 1926).

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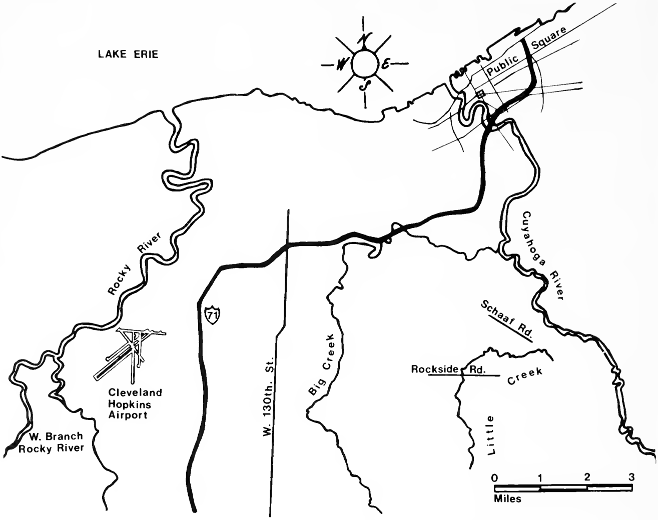


Fig. 1. A sketch map showing part of the Greater Cleveland area.

In the early 1880s, Dr. William Clark, Dr. D. T. Gould, and Prof. William Keppler, all of Berea, Ohio, made enormous collections, probably the finest of their kind. One of the collections went to the British Museum, while the second is said to be in the American Museum (Hyde 1928). Later, the elder Bungart and his son collected many specimens from near their home on the Vermilion River. This entire collection (probably the third best) is in the Cleveland Museum of Natural History.

Because the fossil fishes were large enough to attract the interest of the general public, they started receiving the attention in 1924 of many workers from the museum, including Hyde (1926, 1928, 1965), Newberry, Dunkle, Bungart, and others. The plant remains, however, were ignored. During the I-71 excavation project in 1965, many more fossil specimens from the Cleveland Shale were salvaged and added to the museum collection (Scheele 1965). They contain well preserved remains of both plants and fishes. The plants of the Cleveland Shale from the Cleveland localities have not been previously studied and there is, to date, no publication on these plants. With this background, the research described herein has been undertaken to investigate the macrofossil remains of plants of the Cleveland Shale. A future study of the spores of the shale is anticipated.

This first, preliminary communication describes, in a general way, the plant remains from the museum collection currently being studied.

Material and Methods

The compression specimens sometimes consist of both part and counterpart. Many, however, are either part or counterpart. These are studied with hand lens and stereomicroscope in order to understand their morphology. A few of the specimens are permineralized. One of them was degaged from the matrix. In order to do this, the rock matrix around the specimen was softened by immersing it in 10 percent hydrofluoric acid for a few days; after washing it thoroughly in water, the softened rock was removed by scraping it out with a fine pointed probe under the low power of a stereomicroscope.

A piece of petrified wood was cut and etched with 40 percent hydrofluoric acid. After washing with water and allowing it to air dry, a thin layer of the organic cellular structure was embedded in a cellulose acetate film and removed as a section by the usual peel technique (Andrews 1961).

Description

The specimens studied for this report fall into three broad categories:

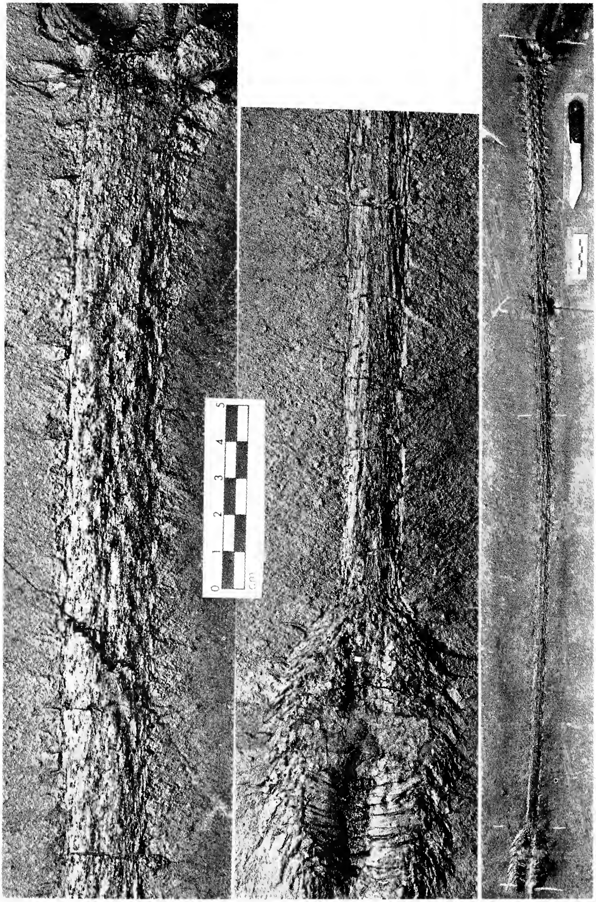
A. Lycopsida
B. Progymnospermopsida
C. Insertae Sedis

A. Lycopsida

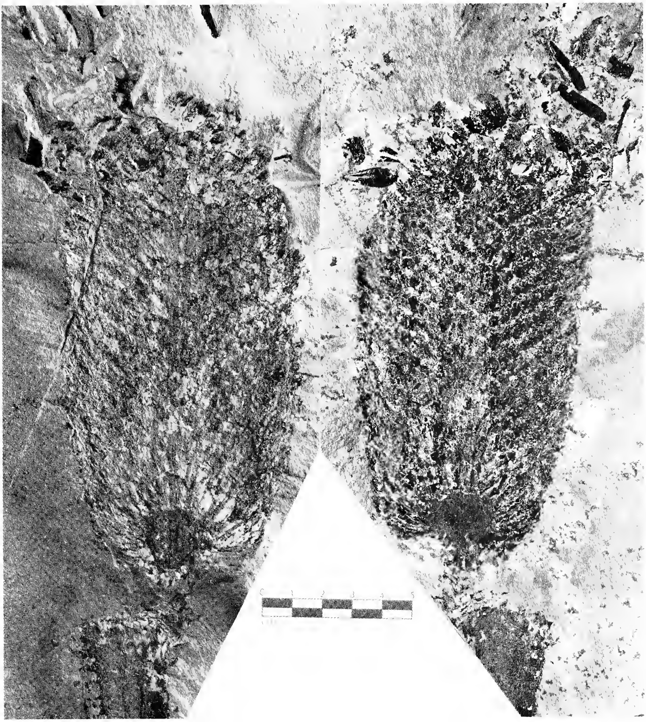
Six specimens are described under this group.

Specimen 1. CMNH No. 8137; Pl. I

This specimen, exposed as part and counterpart, was collected from the intersection of I-71 and West 130th Street in Cleveland when Interstate Route I-71 was being constructed. The specimen is a compression of a large branch measuring 3 ft 11 in. (119.5 cm) in total length including the

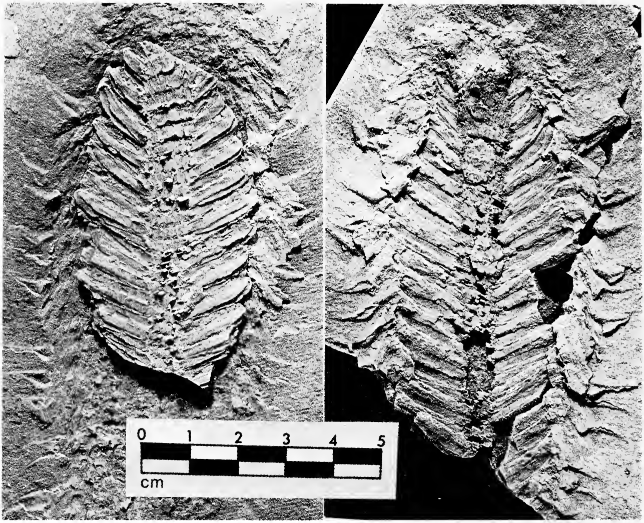


Pl. I. Bottom: a lycopsid specimen with cone at the apex; center: apical portion enlarged; top: basal portion enlarged.



Pl. II. Part (left) and counterpart of Specimen 2, a lycopsid cone.

3.5 in. of a globular conelike crown. The stem is unbranched and is 2.5 cm wide at the base, narrowing gradually to 1.5 cm at the attachment of the apical cone, which is 8.4 cm long and 6 cm wide in the middle portion, narrowing at both ends to about 3 cm. The central axis of the cone is 1.3 cm thick and bears many sporophylls in a tight, shallow helix, or in close whorls. Each sporophyll is 1.2 cm long and 0.2 cm wide and has a midvein. The branch bears elongated leaf base scars arranged alternately in vertical rows. There are thick transverse marks on the surface of this

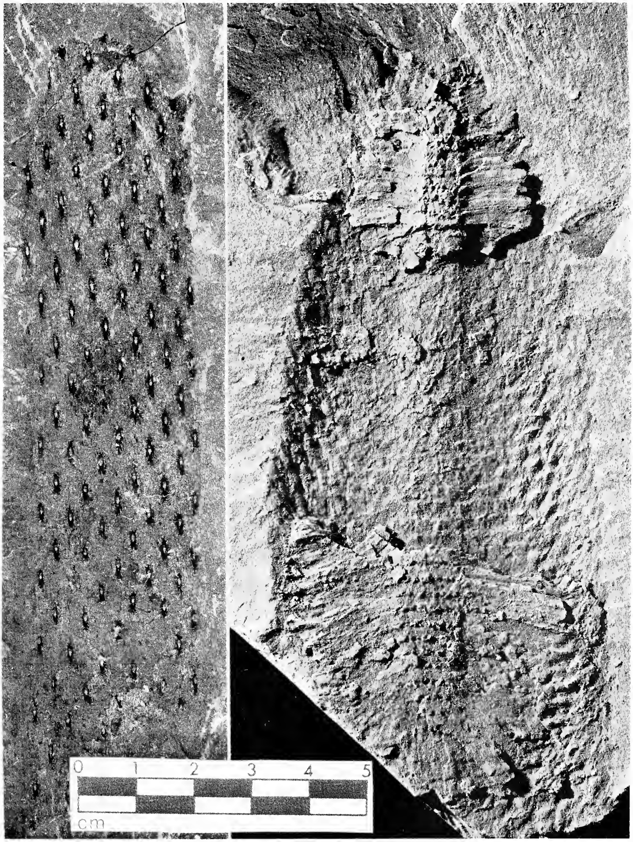


Pl. III. Part (left) and counterpart of Specimen 3, a lycopsid cone.

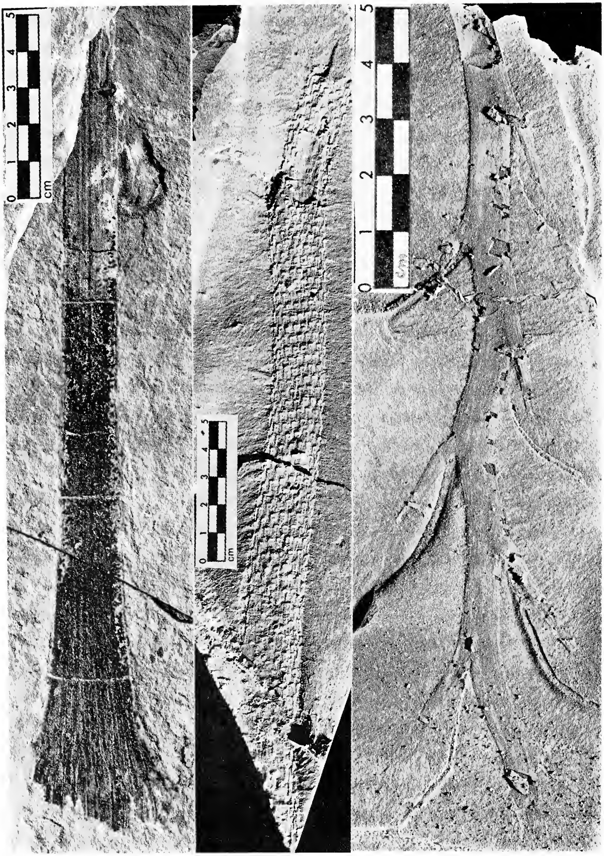
branch. The distance between the two adjoining marks is greater toward the base than toward the apex. The branch axis shows small spinelike structures on the two edges. These outgrowths, probably leaves, or leaf fragments, are about 1 cm long and 3 mm broad at the base narrowing to the tips.

Specimen 2. CMNH No. 8138; Pl. II

This compression of a large lycopsid cone is exposed on the shale in part and counterpart. This specimen is from the same locality as Specimen 1. The cone is 13.5 cm. long, and attached to a small piece of axis 5 cm long and 3 cm wide. The cone is 7.5 cm wide in the middle portion narrowing at both the ends to 5.5–5.8 cm, thus giving an elliptical shape to the whole cone. The central axis of the cone is 1.8 cm wide, bearing many sporophylls in a shallow helix or in close whorls. Each sporophyll is 1.8 cm long and 0.4 cm broad, lanceolate in shape with a single midvein.



Pl. IV. Specimen 4, right, a lycopsid cone; Specimen 5, a lycopsid axis showing leaf scars.



Pl. V. Specimen 6, center, an axis with *Cyclostigma*-like leaf scars; Specimen 9, bottom, a branched axis; Specimen 10, a leaf impression (?).

Specimen 3. CMNH No. 8972; Pl. III

This specimen, from the same locality as Specimen 1, is a compression of a lycopsid cone, 11.7 cm long and 4.5 cm broad, represented by both part and counterpart. This specimen was broken along a median longitudinal plane with approximately one-half of the cone represented on the part, the other half on the counterpart. Consequently, the cone axis is clearly exposed, and each sporophyll seems to bear a large sporangium on its upper surface. The central axis of the cone measures 0.6 to 1 cm wide. Each sporophyll/sporangium complex is strapshaped, 1.7 cm long and 0.3 cm broad.

Specimen 4. CMNH No. 8970; Pl. IV (right)

This specimen is yet another lycopsid cone, from the same locality as above. It is ovate in shape, 13 cm long and 5.3 cm wide at the lower end, narrowing at the top to 3 cm. The axis of the cone is 1 cm wide and the sporophylls are arranged in a shallow helix or in close whorls. During initial exposure of the specimen, it was broken in a way that shows, at either end, the cone axis bearing sporophyll/sporangium complexes, whereas the middle part of the specimen illustrates surface features of the cone in an impression. Each sporophyll/sporangium complex is 1.2 cm long and 0.2 cm wide.

Specimen 5. CMNH No. Nil; Pl. IV (left)

This compression of an axis 13.5 cm long and 2.8 cm broad shows elongated leaf cushions helically arranged and separated from each other by a distance of about 0.55 cm. Each leaf cushion measures 4 × 1 mm and has a leaf scar.

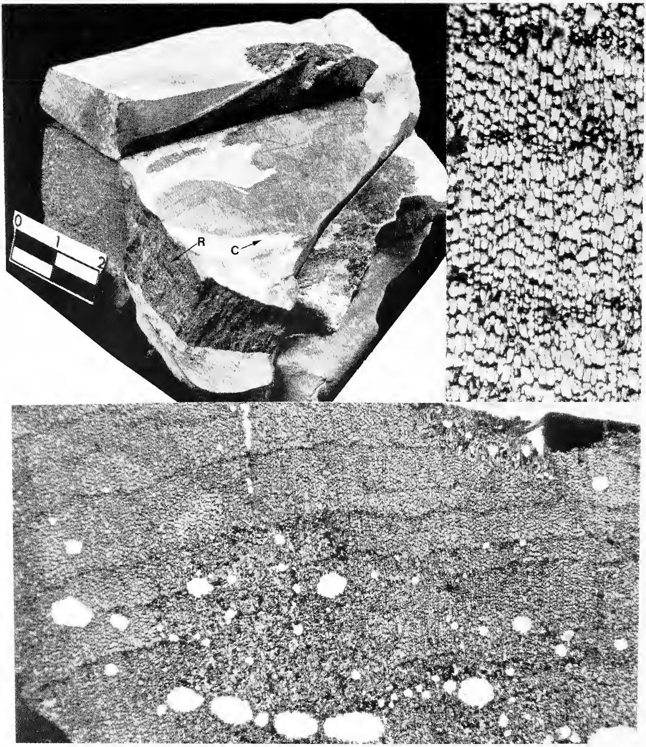
Specimen 6. CMNH No. 8143; Pl. V (center)

This compression of an axis is 27 cm long and 1.8 cm broad, showing close spirals of distinct leaf cushions. Each roundish cushion is of 1.7 cm diameter, with a flattened circular leaf scar. The specimen was collected from the I-71 locality.

B. Progymnospermopsida

Specimen 7. CMNH No. 7068; Pl. VI

The specimen was broken into pieces as shown in Pl. VI, top left. It is a piece of petrified axis, about 6 cm wide along the transverse surface and 2 cm long. This has been studied by taking peel sections from the transverse and longitudinal surfaces. Preliminary examination shows tracheids



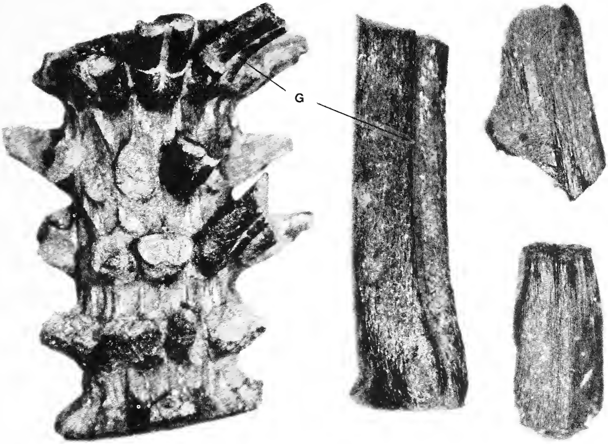
Pl. VI. Specimen 7, top left, a petrified piece of secondary wood. C: Cross; R: Radial longitudinal. Bottom: a cross section showing six growth rings magnified 15 times. Top right: a portion of the cross section enlarged 60 times.

in rows with narrow medullary rays and also distinct growth rings in the decorticated secondary wood. Primary wood and pith are absent.

C. Insertae Sedis

Specimen 8. CMNH No. Nil; Pl. VII

This specimen is a partially permineralized axis with appendage bases



Pl. VII. Left: a piece of degaged axis (Specimen 8) of undetermined taxonomic affinity showing appendage stalks in whorls, enlarged 15 times: G (grooves). Center: a broken-off appendage stalk, magnified 35 times. Right, top and bottom, pieces of appendage stalks magnified 35 times.

attached. A successful degaging exposed the tiny piece of an axis measuring 7 mm X 3 mm. The appendage bases, rather stout and cylindrical, are arranged in whorls around the axis. Distance between two successive whorls is 1 mm. Each appendage is grooved on the abaxial side, and is 1 mm thick at its base. These appendages are broken and their total length is unknown. The maximum preserved length is 3.5 mm. Attached to this axis fragment are five whorls, each of 12 appendage bases. Between each whorl the axis bears grooves and ridges (each ridge corresponding to an appendage base) that alternate in successive internodes.

Specimen 9. CMNH No. 8146; Pl. V (bottom)
This is a compression of a branched axis. The 0.2-cm thick branches are thinner than the main axis, which measures 0.7 cm thick and 14 cm long. The six branches are alternately arranged. The distance between two

successive branches is 1.8 cm. The branches taper to their tips and are spread in one plane. Each branch makes an angle of c. 20 degrees with the main axis. The surface of the axis and the branches is smooth. The specimen comes from the same locality as Specimen 1.

Specimen 10. CMNH No. 7135; Pl. V (top)
This broomlike impression contains a thin carbon film at some places. Total length is 21.3 cm and the width is 1.3 cm at one end, gradually flaring to 2 cm at the other. It is characterized by fine ribs. The distance between two adjoining ribs is 0.2 cm in the flared region and less than 0.1 cm in the lower region. There are also 6 crosswise ridges, possibly cracks, on the axis. The distal margin of the flared region has the irregular outline of the region of a large leaf from which a lamina had been torn.

Conclusion

Of the specimens thus far examined from the collection of the Cleveland Shale present in the Cleveland Museum of Natural History, six (Specimens 1-6) are lycopsids, three (Specimens 8, 9, 10) cannot be, as yet, identified with confidence, and one (Specimen 7) is probably a progymnosperm. Specimen 7 is secondary wood, possibly of *Callixylon,* but because the distinguishing character of radially banded grouped pits has not been yet observed, a positive identification cannot be made till it is studied in detail at a later date. *Callixylon* is the stem of a plant known as *Archaeopteris* (Beck 1960). The presence of *Callixylon* wood in the Cleveland Shale would be no surprise since the Cleveland Shale is part of the same black shale facies from which *Callixylon* has been discovered in abundance in Kentucky and Indiana (Hoskins and Cross 1951). *Callixylon* is often associated with *Archaeopteris* vegetative and fertile remains, but I have not yet found any *Archaeopteris* in our collection, unless Specimen 9 proves to be a branched rachis of an *Archaeopteris* "frond." The anatomy of *Archaeopteris* "fronds" (planated lateral branch systems) has been studied in detail by Carluccio, Hueber, and Banks (1966), and Beck (1971), and the anatomy of its stem by Berry (1932), Arnold (1929, 1930, 1931), Beck (1970, 1979), and others. From the Ohio black shale, well-preserved *Callixylon* has been investigated by Hoskins (1930), and Hoskins and Blickle (1940). The age of the locality at Beaver Pond, Adams County, Ohio is given by Hoskins and Blickle (1940) as Upper Devonian. However, Hoskins and Cross (1951), in their study of plants of the New Albany Shale, discussed the age of the Cleveland Shale member and suggested that it is part of the Devonian-Mississippian transition zone.

Of the ten specimens described in this report, six are lycopsids, thus showing their abundance in the Cleveland Shale. These lycopsids largely resemble *Prolepidodendron, Protolepidodendron, Archaeosigillaria* (see Arnold 1939) and *Lepidodendropsis* (Read 1955). One specimen (6) resembles a *Cyclostigma.*

The presence of numerous, large lycopsid cones is an outstanding feature of the Cleveland Shale flora. Normally the vegetative parts of the lycopsids are more common than fructifications. The nature of particular lycopsid cones, whether homosporous or heterosporous, is yet to be determined. However, spores freed at random from the sporophyll/sporangium complexes of several different specimens and treated with Schulze's solution are of two sizes.

The well-defined growth rings in the progymnospermous secondary wood (Specimen 7) need to be mentioned. The development of growth rings suggests that the climate during this period might have been characterized by seasonal fluctuations. On the other hand, growth rings might also be explained as the result of regular fluctuations in moisture availability.

Specimen 8, although unidentifiable with confidence at this stage of the investigation, is especially interesting since it has some features (distinctly whorled appendages, grooved and ridged internodes) that suggest a possible sphenopsid affinity. The possibility that it is a lycopsid cannot be entirely ruled out, however, since sporophylls of lycopsid cones in very shallow helices may simulate a whorled condition, and the internodal ridges might be simply the decurrent bases of such sporophylls. Anatomical investigation of this specimen will probably solve the problem of its taxonomic affinity.

Specimen 10 is important because it adds to the taxonomic diversity of the flora. This specimen may be a fragment of a large *Psygmophyllum*-like leaf.

This preliminary report presents some highlights of the types of plants in the Cleveland Shale flora. Further extensive detailed study of every specimen will lead to their identification and will hopefully be useful in comprehending the nature of the flora and its stratigraphic placement—whether it falls in the Assemblage zone VI (*Archaeopteris* zone) or zone VII (*Rhacophyton* zone) (Banks 1980) or yet another zone of post-Famennian age.

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References

Andrews, Henry N., Jr. Studies in paleobotany. John Wiley & Sons: 1961.

Arnold, C. A. The genus *Callixylon* from the Upper Devonian of central, western New York. Papers Mich. Acad., 11:1-50; 1929.

——. Bark structure of *Callixylon* Bot. Gaz., 90:426-431; 1930.

——. On *Callixylon newberryi* (Dawson) Elkins and Wieland. Contrib. Univ. Mich. Mus. Paleont., 3:207-237; 1931.

——. Observations on fossil plants from the Devonian of eastern North America *IV.* Plant remains from the Catskill delta deposits of northern Pennsylvania and southern New York. Contrib. Univ. Mich. Mus. Paleont., 5:271-314; 1939.

Banks, Harlan P. Floral assemblages in the Siluro-Devonian. Biostratigraphy of fossil plants. Dowden, Hutchinson and Ross; 1-24; 1980.

Banks, P. O., and Feldmann, R. M. Guide to the Geology of Northeastern Ohio. Northern Ohio Geological Society, 1-168; 1970.

Beck, C. B. The identity of *Archaeopteris* and *Callixylon.* Brittonia, 12: 351-368; 1960.

——. The appearance of gymnospermous structure. Biol. Rev., 45:379-400; 1970.

——. On the anatomy and morphology of lateral branch systems of *Archaeopteris.* Am. Jour. Bot., 58:758-784; 1971.

——. The primary vascular system of *Callixylon* Rev. Paleobot. Palyno., 28 (2):103-115; 1979.

Berry, E. W. A remarkable specimen of *Callixylon newberryi* (Dawson) Elkins et Wieland, from the Ohio shale. Ohio Jour. Sci., 32:385-388; 1932.

Carluccio, L. M.; Hueber, F. M., and Banks, H. P. *Archaeopteris macilenta,* anatomy and morphology of its frond. Am. Jour. Bot., 53:719-730; 1966.

Cross, A. T., and Hoskins, J. H. Paleobotany of the Devonian Mississippian black shales. Jour. Paleontology, 25:713-728; 1951.

——. The Devonian-Mississipian transition flora of east-central U.S. Third Congr. de Strat. et de Geol. du carbonifere-Heerlen, 113-122; 1951.

Hoover, Karl V. Devonian-Mississippian shale sequence in Ohio. Div. Geol. Surv. Ohio. Information Circular No. 27:1-154; 1960.

Hoskins, J. H. The genus *Callixylon* in Ohio. Ohio Acad. Sci. Proc. 8 (7): 410-411; 1930.

Hoskins, J. H., and Blickle, A. H. Concretionary *Callixylon* from the Ohio Devonian black shale. Am. Midland Naturalist, 23:472-481; 1940.

Hoskins, J. H., and Cross, A. T. The structure and classification of four plants from the New Albany shale. Am. Midland Naturalist, 46:684-716; 1951.

Hyde, J. E. Collecting fossil fishes from the Cleveland shale. Natural History, 26 (5):497-504; 1926.

——.Fossil fishing in Cleveland shale. Pub. CMNH, 1 (1):1-12, 1928.

——.Fossil Dig. Explorer 7 (4):28-31; 1965.

Read, C. B. Floras of the Pocono formation and Price sandstone in parts of Pennsylvania, Maryland, West Virginia and Virginia. Geol. Surv. Prof. Paper, 263:1-32; 1955.

Scheele, W. E. Fossil Dig. Explorer, 7 (3):5-8; 1965.

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