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Authors

Henrikson, Lael S
Yohe, Robert M, II
Newman, Margaret E
[et al.](#)

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Freshwater Crustaceans as an Aboriginal Food Resource in the Northern Great Basin

LAEL SUZANN HENRIKSON, Bureau of Land Management, Shoshone District, 400 W. F Street, Shoshone, ID 83352.

ROBERT M. YOHE II, Archaeological Survey of Idaho, Idaho State Historical Society, 210 Main Street, Boise, ID 83702.

MARGARET E. NEWMAN, Dept. of Archaeology, University of Calgary, Alberta, Canada T2N 1N4.

MARK DRUSS, Idaho Power Company, 1409 West Main Street, P.O. Box 70, Boise, ID 83707.

Phylloponds of the genera Triops, Lepidurus, and Branchinecta are common inhabitants of many ephemeral lakes in the American West. Tadpole shrimp (Triops spp. and Lepidurus spp.) are known to have been a food source in Mexico, and fairy shrimp (Branchinecta spp.) were eaten by the aboriginal occupants of the Great Basin. Where found, these crustaceans generally occur in numbers large enough to supply abundant calories and nutrients to humans. Several ephemeral lakes studied in the Mojave Desert and northern Great Basin currently sustain large seasonal populations of these crustaceans and also are surrounded by numerous small prehistoric camp sites that typically contain small artifactual assemblages consisting largely of milling implements. Although it seems likely that prehistoric peoples would have exploited such a seemingly valuable resource, direct archaeological evidence for phyllopond use thus far has been lacking. Attempts to extract protein residues from certain artifacts found at such lake sites in southern Idaho, as well as the exploration of other avenues of indirect evidence, have recently been undertaken in an attempt to establish the merit of the "shrimp camp" hypothesis.

OVER the last several decades, a number of archaeologists working in the Great Basin has considered the significance of ephemeral ponds in the subsistence practices of prehistoric aboriginal groups. The focus of the authors' current research on the Snake River Plain in southern Idaho is to explore what has previously been suspected but unsupported due to lack of tangible evidence—that phylloponds, several species of freshwater crustaceans native to many ephemeral ponds on the plain, were used as a food source by the prehistoric inhabitants. Since these invertebrates are also found elsewhere in western North America, the implications of this study are far-reaching.

Because of the unique challenges inherent in formulating and testing a hypothesis where little or no archaeological evidence may be obvious

and specific ethnographic data are sparse, protein residue analysis of lakeshore artifacts was used as a means of assessing the possible aboriginal use of freshwater phylloponds. Half of the artifacts submitted for analysis tested positive for tadpole shrimp (*Lepidurus*), suggesting the processing of these phylloponds at several separate archaeological sites. While the results are strictly preliminary at this point, it is hoped that they will serve as an impetus for further research efforts to evaluate the significance of phylloponds in the aboriginal diet.

ENVIRONMENT OF THE SNAKE RIVER PLAIN

The unique topographic features characteristic of the Snake River Plain were formed by basalt flows exuding from numerous fissure eruptions

dating between several million years to only 2,000 years in age. These flows have created a landscape of rolling pressure ridges, swales, and basins of various sizes, along with isolated knolls and buttes. The areas of lowest relief often serve as natural catchment areas for winter snowmelt and spring rains, with water often reaching depths of three to four feet in these depressions during wet years. The locations of these water catchments or ephemeral ponds are obvious to the observer due to the absence of vegetation of any kind. As water depth decreases with evaporation, the ponds grow sedges and other hydrophilic grasses, which disappear in the heat of summer. By August, the ponds are dried, cracked, and entirely devoid of plant life.

Understandably, during the spring and early summer months, these ponds are a remarkable attractant for waterfowl, including the green-winged teal (*Anas crecca*), northern pintail (*A. acuta*), cinnamon teal (*A. cyanoptera*), northern shoveler (*A. clypeata*), and Canada goose (*Bran-ta canadensis*). Large game, including pronghorn (*Antilocapra americana*), deer (*Odocoileus hemionus*), and elk (*Cervus canadensis*), as well as smaller animals such as hares (*Lepus californicus*), rabbits (*Sylvilagus* spp.), and marmots (*Marmota flaviventris*), are also attracted in significant numbers.

The high frequency of prehistoric sites surrounding these ponds is a strong indication that the aboriginal inhabitants found them attractive as well. While archaeologists have assumed that ephemeral ponds were appealing for the most obvious reasons—water and vertebrate game—freshwater invertebrates as a resource have been, for the most part, overlooked.

RELEVANT TAXA

Phyllopods are members of the subphylum Crustacea belonging to the class Branchipoda, which consists of the orders Anostraca (fairy and brine shrimp), Notostraca (tadpole shrimp), and

Conchostraca (clam shrimp). Members of the first two orders have been previously documented on the central Snake River Plain, but the true extent of their taxonomic diversity, range, and numbers in this region is currently unknown. However, a recent examination of several dozen fairy and tadpole shrimp specimens collected from seven different pond localities within the study area of this project revealed a species of fairy shrimp similar to *Branchinecta coloradensis*. This species is found west of the Rockies, primarily in the Great Basin, but has not previously been known to exist in Idaho (D. Belk, personal communication 1997). Likewise, the tadpole shrimp from these same ponds is *Lepidurus bilobatus* (Packard), a species known to exist in Colorado, Arizona, Utah, Montana, and now Idaho (D. Belk, personal communication 1997). In general, tadpole and fairy shrimp have been found to occur in abundance throughout most of North America (Pennak 1989; Dodson and Frey 1991; Thorpe and Covich 1991).

Fairy shrimp (*Branchinecta* spp.), identified from ponds on the Snake River Plain and common to playa lakes throughout the Great Basin, range in size from 7 to 100 mm. in length (Dodson and Frey 1991). They have translucent bodies usually made up of 19 or more segments with compound eyes on the end of a stalk. Tadpole shrimp (*Triops* and *Lepidurus*) are more highly segmented than members of Anostraca and have between 35 and 71 pairs of legs. The majority of the anterior portion of the body is covered by a shield-like carapace (Fig. 1). Adults range in size from 10 to 58 mm. (Pennak 1989:346-347). Specimens recently recovered from local ponds in southern Idaho have been noted to reach 40 mm. in length. Members of the order Conchostraca consist of small shrimp encased in a bivalve-like chitinous shell, but because of their diminutive size (2 to 16 mm. [Dodson and Frey 1991:764]), it is unlikely that they were a focus of prehistoric exploitation, and will not be further discussed.

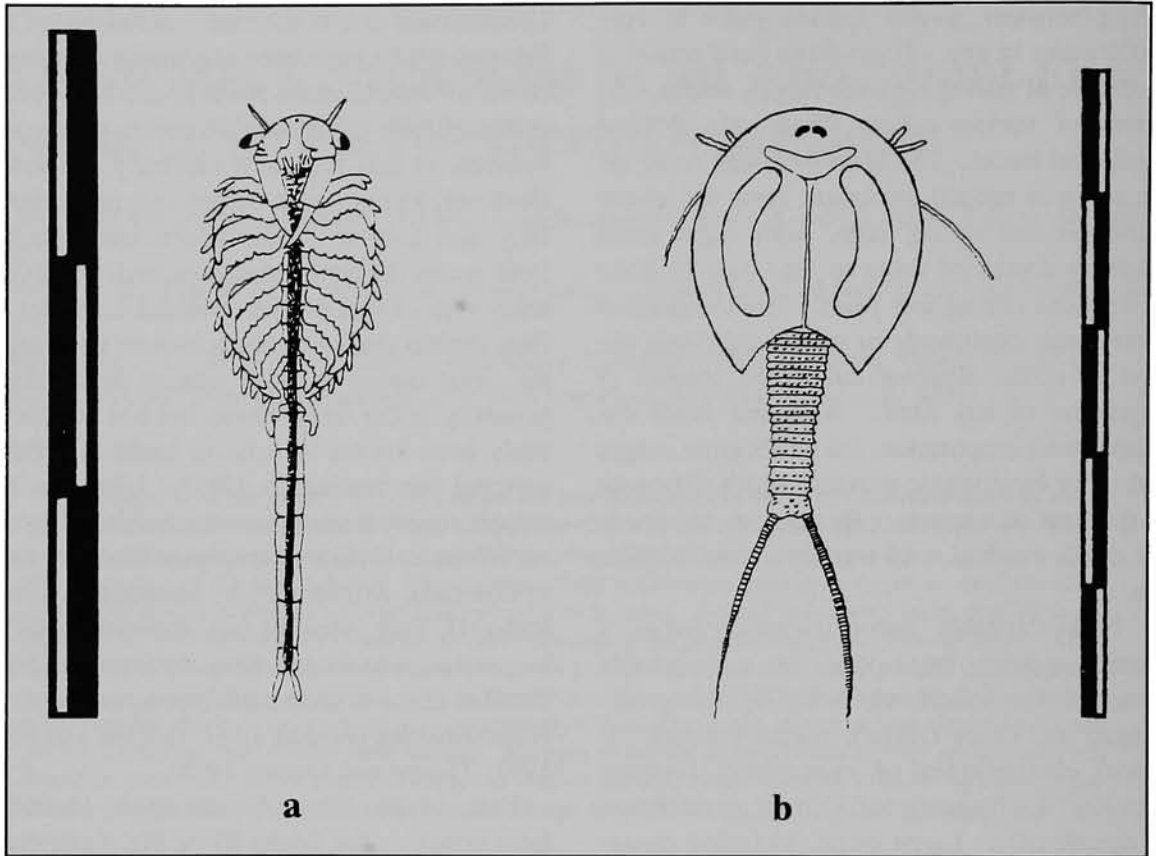


Fig. 1. Generalized sketches of major phyllopod genera found on the Snake River Plain: (a) *Branchinecta* (fairy shrimp); (b) *Triops* (tadpole shrimp). (Redrawn from Pennak [1989]). Scale in cm.

Fairy and tadpole shrimp, like all phyllopods, live only in vernal ponds and lakes where carnivorous insects and macrometazoans are lacking (Pennak 1989; Dodson and Frey 1991: 724). With the exception of *Artemia* in the Great Salt Lake, Mono Lake, and other extremely saline bodies of water, fairy and tadpole shrimp are completely absent from permanent freshwater bodies of water (Pennak 1989:354). Since hydrogen ion concentration and salinity vary considerably during the often short existence of ephemeral ponds, phyllopods have developed physiological flexibility that allows them to adjust to their rapidly changing environment (Pennak 1989:354). Another interesting adaptation of the phyllopods is the ability of their eggs to

remain viable in desiccated lakes from one season to the next. It has been demonstrated that the eggs can withstand freezing, intense heat, and extreme aridity for extended periods of time, and can successfully hatch after 15 years in laboratory storage (Pennak 1989:353).

The caloric value of phyllopods is potentially quite high. In studying the life history of *Branchinecta mackini*, Daborn (1977:165) calculated that the maximum biomass per m.² for this fairy shrimp was 580 mg. of dry weight (approximately 2,700 calories per m.²). Assuming that similar values apply to *Triops* and *Lepidurus*, phyllopods in general would prove a tremendous source of calories and protein to birds and humans. Additional studies to specifically evaluate

Lepidurus nutritional values are currently underway.

ETHNOGRAPHIC ACCOUNTS

Ethnographic accounts of phyllopod use in the Great Basin are infrequent, at best. Chamberlin (1911:337) discussed the use of crickets as a food and described the taste of roasted crickets as being "compared by the Indians to the *shrimp*, which they accordingly term 'fish cricket'." Brine shrimp were apparently extensively used by the native peoples occupying the area surrounding the Great Salt Lake (Morgan 1947). The following account describes the flavor of *Artemia* (Morgan 1947:376):

The gulls fed upon (brine flies, shrimp) . . . and at one time the Indians did also. Tastes that their possessors regard as more discriminating would reject all three as food, but the brine shrimp, at least, has had the gastronomic sanction of respectable authority. Dr. James Talmage in September 1892 after rinsing brine shrimp in fresh water and cooking it with a little butter and pepper, pronounced it "actually delicious," and in this was only echoing the verdict of David L. Davis, master of the *Cambria*. As the crustacean is only one-fourth of an inch long, however, it would require great numbers to satisfy the average appetite.

Brine shrimp were also eaten by Northern Paiute groups at Mono Lake, along with the larvae and pupae of the brine fly (*Hydropyrus hians*) (Davis 1965). However, the extent to which they were used has never been clarified; Merriam's (1955) interpretation of the Mono Basin Paiute term for the brine shrimp (*ewamaka*) and the Bridgeport Paiute term (*kuzabe*) are both the same for the immature, free-swimming brine fly larvae.

Only one direct account of the use of tadpole shrimp as a food source is known to exist for North America, and comes from Mexico in the early 1930s. Apparently, Indians in the Lago de Texoco area were observed using *Triops* as food during the winter months (Creaser 1931). Unfortunately, this one ethnographic account is ex-

tremely limited in detail. In contrast, what are presumed to be similar invertebrate gathering practices, such as the collection of brine fly larvae (*Hydropyrus hians* [Mono Basin Paiute *kutsavi*]) on the shores of Mono Lake in California in ethnographic times, are well documented (e.g., Steward 1933; Davis 1965). In fact, *kutsavi* is considered to have been such an important component of the Paiute diet that the Mono Basin Paiute are referred to by other Northern Paiute peoples as *kucadikadi*, or "eaters of the brine fly pupae" (Fowler and Liljebland 1986:464).

It is clear that such practices as harvesting phyllopods were not commonly recorded in the ethnographic record of the Great Basin. If the tadpole shrimp played an important role in the subsistence regimen of the early inhabitants of the Snake River Plain and/or the Great Basin in general, then why were such practices not described to ethnographers by their native informants? It may have been simply an issue of asking the right questions—ethnographers would not likely know to ask whether their informants ate phyllopods, and the information might not be readily volunteered. Perhaps the frequency of predictable freshwater shrimp hatches diminished within the last century due to climatic variability; unlike the *kutsavi* harvest, which was generally an annual event in eastern California, a rainy season sufficient enough to result in a significant hatch of phyllopods might occur only a few times within the most recent generations of indigenous populations. Also, as noted by Penak (1989:355), certain phyllopod species may be abundant for several years in a particular pond then become absent in successive years, even when ponds are full of water. It is possible that ponds became unpredictable in their potential yields of crustaceans within the last century, causing indigenous peoples to adjust their resource foci. Furthermore, the introduction of the horse and other elements of Plains culture into the Snake River Plain by ca. A.D. 1730

may have redirected or completely replaced certain facets of the preexisting subsistence schedule (Steward 1938; Shimkin 1986; Pavesic and Studebaker 1993), perhaps decreasing, or even eliminating, the importance of all ephemeral lake resources.

A problem facing archaeologists attempting to reconstruct ancient subsistence is the fact that not every behavior of indigenous peoples was recorded by ethnographers, and not all activities recorded by cultural anthropologists are clearly discernible in the archaeological record. The strict reliance on ethnographic data for the majority of our models of prehistoric subsistence may, indeed, prevent us from exploring other potential resources that may have been of greater importance at different periods of time during the distant past. An Idaho example of an archaeologically expressed dietary constituent that is absent from ethnographies of the region is the exploitation of the freshwater mussel (*Margaritifera margaritifera*), the shells of which are a common component of prehistoric encampments along the middle Snake River (cf. Gould and Plew 1996:23).

On the other hand, certain food remnants do not lend themselves to easy recognition or recovery using traditional archaeological field collection techniques, which would include most invertebrates with noncalcareous body coverings. Insects, a common food source in western North America, are rarely recovered from archaeological contexts (Sutton 1988, 1995). For instance, based on cultural assemblages recovered using standard archaeological data collection methods, the Mono Basin Paiute use of *kutsavi* would be extremely difficult to discern archaeologically; thus, this important aspect of their subsistence strategy (Davis 1965; Fowler 1986) could easily be missed.

PREVIOUS RESEARCH

To date, little research into the possibility of prehistoric phyllopod exploitation has been con-

ducted. One of the few anthropologists in recent years to raise the question of freshwater shrimp as food was Malouf (1966:38), who observed that "The Great Salt Lake does contain a small 'brine shrimp,' but I am not sure the natives were aware of these, and if so, could they have been seined and used for food?"

Based on his surveys in the Sacramento Valley during the late 1970s, Roop (1984) recognized that the significance of ephemeral ponds (i.e., vernal pools) had been neglected in the development of aboriginal subsistence models in the region. He surmised that freshwater invertebrates would have been as attractive to prehistoric groups as any other resources available at the ponds, and that groundstone implements commonly found at vernal pool sites could have been used to grind or process fairy and/or tadpole shrimp, as well as plant foods.

Yohe (1987) documented the existence of phyllopods in the Mojave Desert of southern California, but was frustrated by the dearth of archaeological and ethnographic evidence supporting the use of these invertebrates as aboriginal food items. Due to the nature of their composition, the chitinous exoskeletons of these creatures would deteriorate rapidly in open archaeological sites (Yohe 1987:7). Even in depositional contexts where they may be more readily preserved (e.g., dry caves), identifiable remains of phyllopods could easily pass through 1/8-inch mesh unnoticed. However, Yohe (1987:7) postulated that they could have been eaten whole or processed with groundstone for drying and later storage; therefore, under the appropriate conditions, they might be preserved in human paleofeces.

In southern Idaho, it has long been recognized that ephemeral lakes hold abundant food resources (e.g., Gruhn 1961:5; Reed et al. 1986). Druss and Reale (1989) noted that a high frequency of prehistoric sites is found at ponds on the Snake River Plain. For example, at site 10JE90, Reale recorded a series of light lithic

scatters, buried artifacts, and a rock alignment near a game trail around the shore of such a lake (Druss 1989). Such lake sites have also been located near Wilson Butte Cave (Druss and Reale 1989) and in the Minidoka area (Druss and Druss 1982).

Although it has long been suspected that phylloponds inhabited the abundant vernal ponds and lakes found in the central Snake River Plain, as of 1989, they had not been identified in the area. However, along with the number of lakeside archaeological sites, as well as Roop's (1984) work on vernal ponds in the Roseville, California area, the possibility that shrimp were located in the region led Druss (1989) to investigate the distribution of these lakes in the Shoshone District area of the Bureau of Land Management (BLM).

An inspection of satellite imagery revealed hundreds of ephemeral lakes throughout the Shoshone District area, identified by the Idaho Department of Water Resources from a LANDSAT Image taken during May 1983.¹ This was an *El Niño* year when there was abundant snow in the region well into spring. The fact that there are hundreds of these lakes, possibly containing small but edible crustaceans, led Druss and Reale (1989) to postulate that such water sources, containing significant quantities of edible invertebrates, were important components of prehistoric subsistence-settlement systems.

Schneider (1996) and Warren et al. (1996) have posited the prehistoric aboriginal exploitation of *Branchinecta* at Silver Lake in the central Mojave Desert based on the presence of constructed rock features or piers extending out into the lake from rock prominences at the edge of the playa. The stone piers would afford easier access to deeper water and eliminate the problem of fine sediment turbidity and disturbance of the shrimp resulting from stepping into the water. A similar cultural manifestation has been identified in the playas of the Snake River Plain (see below).

CURRENT RESEARCH

The massive fire rehabilitation efforts and subsequent cultural resource inventories occurring on public land administered by the BLM in southern Idaho over the last 14 years have allowed archaeologists to conduct intensive pedestrian surveys covering hundreds of thousands of acres in the sagebrush steppe of the Snake River Plain. From the results of these inventories, it is very apparent that the frequency of prehistoric sites strongly correlates with the frequency of ephemeral ponds, as previously proposed (Druss and Reale 1989; Henrikson 1993). Although lithic scatters are often encountered on prominent landforms, such as buttes and knolls, or along the edges of recent lava flows, the highest frequency of such prehistoric sites occurs at ephemeral ponds. Likewise, the most extensive sites containing the widest variety of artifactual material, including ceramic fragments, groundstone implements, and utilitarian implements (e.g., scrapers and expedient tools), are also located along the edges of ponds.

One unique cultural feature noted at several ponds documented during these extensive fire rehabilitation inventories and other archaeological surveys of the surrounding area are the presumably deliberate alignments of small basalt boulders extending from the edges of ponds towards their centers. These rock features have been documented in a variety of forms, ranging from a single row of stones to more elaborate configurations consisting of multiple rows. These rock "alignments" frequently occur at ephemeral ponds associated with prehistoric sites that contain little or no historical elements. As described above, similar features have been recorded recently on the shores of the Silver Lake playa in the central Mojave Desert of California (Schneider 1996; Warren et al. 1996). Schneider (1996) and Warren et al. (1996) hypothesized that the function of these features was related to prehistoric phyllopond harvesting, the

same conclusion reached independently by one of us (LSH) for the Snake River Plain examples. Building stepping stones from the edges of ponds would allow access to deeper water containing perhaps higher concentrations of shrimp and permitting easy collection by seining, possibly with coarsely woven baskets or fine cordage nets.

Research Objectives

In light of the implied significance of ephemeral ponds in prehistoric subsistence on the Snake River Plain and the focus of this research—prehistoric exploitation of phylloponds—several initial primary issues were addressed. First, it was necessary to determine whether phylloponds are present in ponds on the central Snake River Plain. If this proved to be the case, then an effort could be put forth to find archaeological evidence of shrimp exploitation. Because of the fragile nature of phylloponds and the unlikelihood of encountering remains in open archaeological contexts, it was necessary to look for another avenue of inquiry to determine if exploitation of phylloponds was a part of prehistoric subsistence strategies. One such approach believed to have great potential in addressing this particular problem is protein residue analysis. If phylloponds were indeed processed by milling implements at these lake encampments, then it is possible that residues of these invertebrates may still adhere to the surfaces of these artifacts.

During May of 1996, one of us (LSH), accompanied by a Shoshone District BLM wildlife biologist, visited several of the ephemeral ponds within the Shoshone Resource Area in the central Snake River Plain in an attempt to seine the murky waters for evidence of phylloponds. Luckily, because of the ample precipitation during the winter of 1995-1996, most of the ponds held a substantial amount of water. Although the relatively small number of birds at the ponds indicated that it was late in the season for fairy shrimp, limited numbers of *Branchinecta* were noted in all 15 ponds seined. It was suspected

that the peak abundance of fairy shrimp had likely occurred during April and that what was being observed was the last remaining adults in the life cycle (J. Russell, personal communication 1996). However, *Lepidurus* were found in great abundance. These larger invertebrates were quite visible even in shallow areas near the edges of the ponds, and minimal seining produced large quantities. Bulk samples of both fairy shrimp and tadpole shrimp were collected and kept frozen in order to produce an antiserum that would allow for protein residue analysis.

Protein Residue Analysis

Based on the assumption that phylloponds were processed using the groundstone implements commonly discovered at pond sites, 10 groundstone objects recovered from playa sites on the central Snake River Plain were submitted to the University of Calgary for protein analysis. Five of these artifacts were recovered from sites immediately adjacent to playas containing tadpole shrimp. The other five were recovered from sites not directly associated with playas, but were within easy access. All sites chosen for testing occur within the area represented in Figure 2, which contains 452 ephemeral ponds in an area encompassing 127,014 hectares.

The artifacts selected from pond sites included metate fragments from 10LN142 and 10LN114, pestle fragments from 10MA52 and 10MA101, and a mano from 10LN169. Based on the presence of various projectile point types and ceramics, all sites are considered to be multicomponent, representing a time depth ranging from the Archaic to the Late Prehistoric Period. None of these sites has yet been subjected to subsurface evaluation.

Groundstone from sites not directly associated with playas included several metate fragments from the surface assemblage of 10BN389, a large lithic and ceramic scatter situated in a sheltered embayment along the edge of the Craters of the Moon lava flow (Fig. 2). A mano frag-

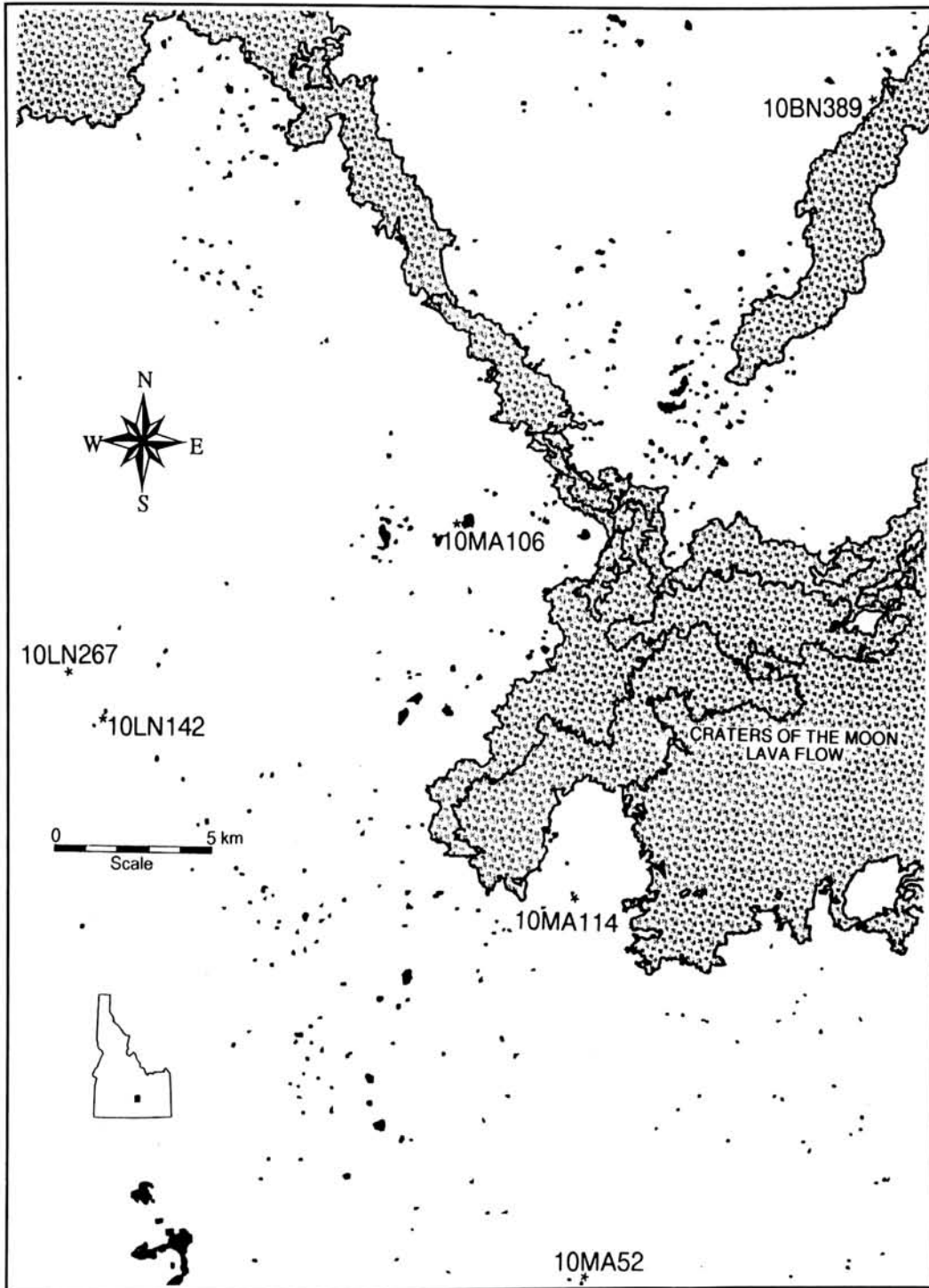


Fig. 2. Area of the central Snake River Plain that is the focus of this study, with the location of sites discussed in the text. All of the dark areas represent ephemeral lakes, many of which are known to contain multiple species of phyllopod.

ment and a metate fragment recovered from 10-LN267, an extensive artifact surface scatter in the western portion of the study area containing a large, circular rock feature, were also submitted, as well as an isolated metate fragment (10-LN141) found in the northwest part of the study area near Sand Butte. Again, none of these sites has yet been subjected to subsurface evaluation.

Although questions concerning the preservation and viability of ancient protein materials have recently been raised (Eisele et al. 1995; Fiedel 1996), there is strong evidence demonstrating the tenacity and longevity of various types of protein molecules. Proteins have been recovered from shells of planktonic foraminifera dating between 2,000 and 4,000 years in age (Robbins and Brew 1990), from dinosaur bones (Miller and Wyckoff 1968), from dinosaur eggs (Voss-Foucart 1968), from a 40,000-year-old frozen mammoth (Prager et al. 1980), and from 1,500-year-old human bone (Cattaneo et al. 1992). Although proteins may not be preserved in their tertiary form, linear epitopes generally preserve well and can be identified by Western blot and other immunological methods (Abbas et al. 1994). Immunological methods have been used to identify plant and animal residues on prehistoric flaked and groundstone lithic artifacts (Hyland et al. 1990; Newman 1990; Yohe et al. 1991, 1992; Kooyman et al. 1992) and in Chumash paint pigment (Scott et al. 1996). Given the viability of proteins under the conditions discussed, there is a high probability that artifacts used in hunting, butchering, plant collection, and processing will also retain adequate amounts of detectable proteins.

Materials and Methods. The method of analysis used for this study is cross-over immunoelectrophoresis (CIEP). Minor adaptations to the original method were made following procedures used by the Royal Canadian Mounted Police (1983) Serology Laboratory, Ottawa, and the Centre for Forensic Sciences (Toronto). Although this test is not as sensitive as radioimmu-

noassay (RIA), it has a long history of use in forensic laboratories, does not require expensive equipment, is reasonably rapid, and lends itself to the processing of multiple samples (Culliford 1964). This method can detect immunoproteins at dilutions on the order of 1 to 30,000, making it a valuable means of identifying trace protein residues. The principle of this method is that all animals produce antibodies that recognize and bind with foreign proteins (antigens) as part of the body's defense system. The ability of these proteins to precipitate antigens from solution is one of their best known properties (Johnstone and Thorpe 1982), and it is this ability that is tested in CIEP.

In this test, the antigen and antibody are driven together by an electrophoretic force instead of simple diffusion, as in the Ouchterlony test. The test is performed in agarose gels with a pH of 8.6. Paired wells, approximately 1.5 mm. in diameter, are punched in the agarose gel 5 mm. apart. The antigen (unknown extract) is placed in the cathodic well of the pair and the known antiserum in the anodic one. The gel is placed in an electrophoresis tank containing a barbital buffer (pH 8.6), and a triple thickness of filter paper is used as a wick to connect the ends of the slides with the buffer. The application of an electrical current, set at a constant 100 v, moves the two reactants toward each other. If the unknown sample contains protein corresponding to the species antiserum against which it is being tested, an extended lattice forms as a result of crosslinking, and a precipitate forms where they reach equivalence concentrations between the two wells. Weak positive reactions, common in archaeological samples, are more readily observed if the gel is dried and stained with a protein stain, such as Coomassie Blue. Appropriate positive and negative controls are run with each gel, positive for species being tested (e.g., deer blood for deer antiserum) and negative for blood of species in which antiserum is raised (e.g., rabbit, if raised in that animal).

Ten 5-percent ammonium hydroxide washes were taken from groundstone artifacts recovered from playa sites noted above. Each wash consisted of a 5 to 10 ml. ammonium hydroxide solution that was placed on the surface of each artifact to soak for 30 minutes. The wash solutions were retrieved using a clean, disposable, plastic needle-point pipet and placed in 1.5 ml. plastic microcentrifuge tubes. The solutions were then frozen and shipped via overnight mail to the University of Calgary. Samples were concentrated by lyophilization, then reconstituted by the addition of 200 μ l of sterile phosphate-buffered saline (PBS). Initial testing of samples was carried out against pre-immune serum (i.e., serum from a nonimmunized animal). A positive result against pre-immune serum could arise from nonspecific protein interaction not based on the immunological specificity of the antibody (i.e., nonspecific precipitation). No positive reactions were found and complete testing of samples was continued against antisera for bear, bovine, cat, chicken, deer, dog, guinea pig, human, rabbit, rat, sheep, elk, and tadpole shrimp.

Antisera obtained from commercial sources are developed specifically for use in forensic medicine and, when necessary, these sera are solid phase absorbed to eliminate species cross-reactivity. However, these antisera recognize epitopes shared by closely related species and will often identify other species within the individual family. *Lepidurus* antiserum was produced at the University of Calgary from frozen specimens submitted by the senior author following established protocol of the Animal Health Services. An extract of *Lepidurus bilobatus* prepared in PBS was used as antigen to produce antiserum in New Zealand rabbits. The resulting antiserum was tested against a wide variety of fish and terrestrial animals and was found to be specific for *Lepidurus*. However, the possibility exists that cross-reactions to other species not tested for (including other genera of phyllopods) may exist.

Results. The results of the CIEP analysis are shown in Table 1. A positive reaction to rabbit antiserum was obtained on one artifact, a metate fragment, from 10LN267. Other members of the order Lagomorpha may be represented by this result, but cross-reactions with other, unrelated species do not occur with this antiserum. The processing of rodents and lagomorphs on milling slabs has been demonstrated elsewhere in western North America (Yohe et al. 1991, 1992). Site 10LN267, a large, multicomponent lithic, ceramic, and groundstone scatter, is located roughly one half mile from a large ephemeral pond. The site includes a large, circular rock feature oriented along the eastern side of north-south trending basalt fissures that hold ice during the spring and summer months. Although the positive reaction to rabbit antiserum on the metate from this site indicates the processing of lagomorphs, this does not eliminate the possibility that phyllopods were also processed at this pond. In order to gain greater insights into the subsistence activities occurring at 10LN267, additional groundstone fragments from the site will be submitted for CIEP analysis in the near future.

Positive reactions for *Lepidurus* antiserum were obtained on five artifacts, representing 50% of the tested sample. As discussed previously, this antiserum is felt to be genus-specific to the antigen against which it was raised. No other positive results for any taxa were obtained from this analysis. The artifacts yielding the positive results for *Lepidurus* residues were from sites directly associated with playas, with the exception of two metate fragments from 10BN389. The playa artifacts include metates from 10LN-142 and 10MA114 and a pestle from 10MA52 (see Fig. 2). Both 10MA114 and 10MA106 include linear rock alignments (Fig. 3). Site 10MA52 consists of a small lithic scatter surrounding Little Lake in the southern portion of the study area. Although 10BN389 is not immediately adjacent to a playa, Zada and Purdy lakes are not more than a kilometer away. Water, game,

Table 1
RESULTS OF CIEP ANALYSIS OF GROUNDSTONE
ARTIFACTS FROM PLAYA SITES IN THE
CENTRAL SNAKE RIVER PLAIN, IDAHO

Cat. No.	Artifact	Result
10BN389-9	metate	<i>Lepidurus</i>
10BN389-10	metate	<i>Lepidurus</i>
10LN141-1a	metate	negative
10LN142-9a	metate	<i>Lepidurus</i>
10LN169-1	mano	negative
10LN267-1	metate	rabbit
10LN267-7	mano	negative
10MA52-1	pestle	<i>Lepidurus</i>
10MA101-1	pestle	negative
10MA114-3	metate	<i>Lepidurus</i>

and/or phyllo pods could be transported from the ponds to the site with little effort.

IMPLICATIONS OF THIS STUDY

Although preliminary, the results of the immunological analysis should serve as an inducement for additional analyses of groundstone from ephemeral lake sites on the Snake River Plain and in other parts of the Great Basin where phyllo pods are known or suspected to exist, or may have existed in the past. If it can be determined that phyllo pods were a critical resource to the prehistoric inhabitants of the plain, inferences regarding regional subsistence and settlement patterns must consider this potentially vital resource. Our knowledge of the nature and life cycle of phyllo pods and ponds must also be greatly expanded in order to understand the degree of dependence and/or influence this resource may have had on seasonal subsistence activities in prehistory.

While ephemeral ponds were obviously a strong attractant to prehistoric peoples (as evidenced by the sheer quantity of archaeological sites located at playa edges), their allure was likely limited to the spring and early summer months when water was available. Although the

wide variety of artifacts recovered from these sites is more indicative of a residential base than a field camp (see Binford 1980; Thomas 1983), the seasonal nature of these ponds strictly limits resource availability to a specific time of year, discounting the possibility that these sites represent the remains of more permanent residential bases. In all likelihood, the projectile points, ceramics, grinding stones, and expedient tools are the remains of long-term field camps, perhaps occupied for several weeks during spring and early summer (although further archaeological studies are necessary to verify this assertion). The numerous lithic scatters situated on knolls and rises in the surrounding area could be indicators of small hunting parties moving from a field camp to locations or stations for hunting game.

Plew (1990) suggested three alternative subsistence strategies for the Shoshoni on the Middle Snake River in southern Idaho that are relevant to any discussion of riverine versus non-riverine resources. The first strategy involves semipermanent to permanent residential units along the river that would focus on aquatic resources (especially salmon). The second strategy applies to transhumant hunters and gatherers whose use of the Snake River fisheries was periodic and overshadowed by a greater dependence on stored tubers (camas) during the winter months. A third strategy concerns only minimal storage of salmon and camas, emphasizing large mammals (deer, elk) during the winter. Assuming that tadpole shrimp and other phyllo pods were a high yield/low cost acquisition resource requiring minimal processing, highly mobile groups could readily incorporate shrimp collecting into their foraging schedule. The location of many ephemeral ponds between the Snake River and certain major camas collecting areas would certainly facilitate easy acquisition of phyllo pods en route.

There are interesting scheduling implications for a subsistence-settlement pattern involving

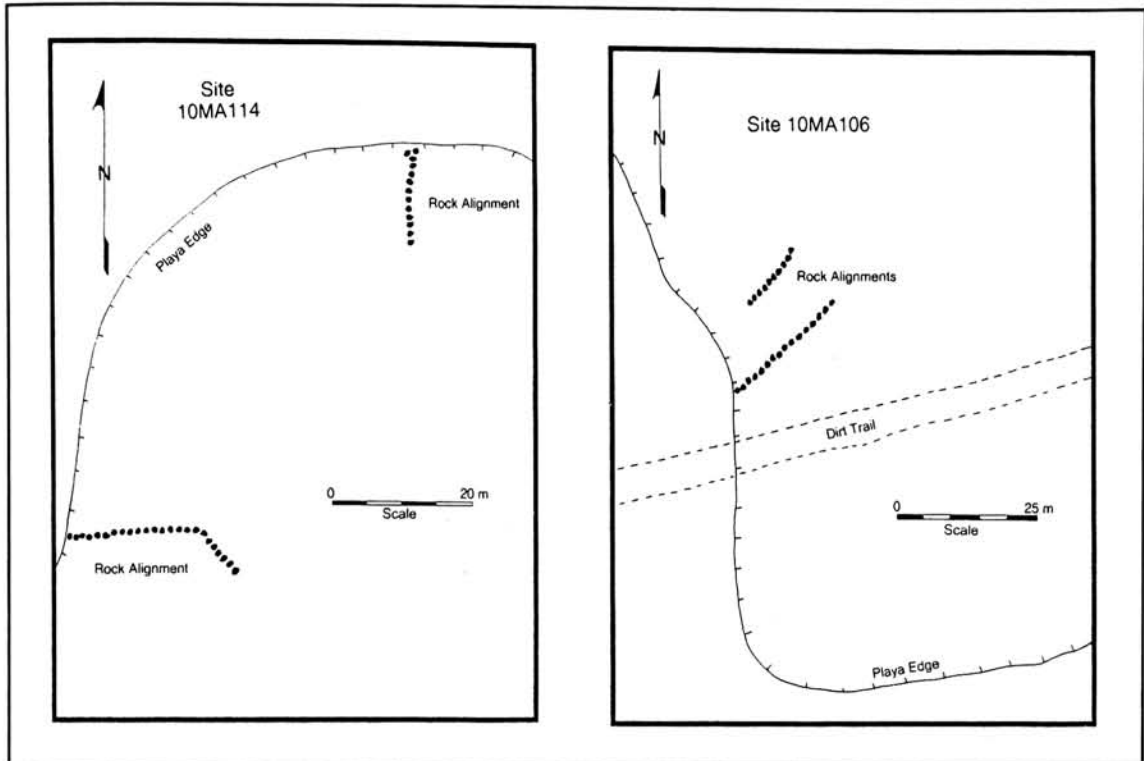


Fig. 3. Rock alignment features extending into playas at 10MA114 and 10MA106. Both playas are known to contain *Lepidurus* sp.

ephemeral lakes and shrimp harvesting on the lava plateau if, indeed, phyllopods were a consistent and reliable resource. For example, chinook salmon and steelhead runs begin to arrive in the area in May (J. Chandler and P. Groves, personal communication 1997). Assuming that modern scheduling is consistent with the past, it is possible that the hunting and gathering people living along the middle Snake River opted to miss these fishing opportunities in order to arrive on the plateau in time for the shrimp harvest, if significant shrimp blooms could be predicted in any way and their ranking as a resource was greater in terms of optimality (which remains to be demonstrated). Another possible and more likely reason to abandon the river in the early spring would have been high flows: the same abundant water which created the lakes could also have created extremely high water in

the Snake River, making aboriginal fishing extremely difficult (J. Chandler and P. Groves, personal communication 1997).

The existence of shrimp camps also has implications for paleoclimatic studies. Shrimp blooms on the lava plateau are cyclical, depending on abundant moisture and other biological variables (Pennak 1989). Comprehensive dating of ephemeral lake campsites and the nonsite occurrences of shrimp themselves may reveal local wet and dry cycles. Furthermore, at least two recent periods when such lakes existed on the lava plateau (in 1983 and 1993) were also *El Niño* years. Therefore, by dating a great many archaeologically and naturally deposited shrimp remains, it may be possible to demonstrate that there were wet/dry climatic cycles on the lava plateau during prehistoric times and that the cycles were a component of global climatic patterns.

CONCLUSIONS

As usual, the implications of preliminary studies such as this one raise many more questions than they answer. Were phyllopods important as a contributing food source throughout prehistory or just during specific time periods? Unfortunately, none of the groundstone artifacts tested in this study can be related to any particular temporal period due to their ubiquity throughout time, and most of the playa sites represented in this sample either have multiple components or unspecified temporal assignments.² Furthermore, the encampments encountered at these particular lakes may represent a palimpsest of various subsistence activities (i.e., seed harvesting, small/large game procurement) that changed perhaps seasonally and/or over the course of time.

One temporally and environmentally related issue that may have major ramifications with respect to shrimp exploitation is the warmer, drier period between 7,500 and 4,000 years ago in western North America (the Altithermal) that appears to have had an appreciable impact on lacustrine habitations in general (cf. Grayson 1993). Phyllopod availability during this time may have been intermittent or even nonexistent. Experimental studies related to the optimality of phyllopod exploitation are clearly warranted as well. Were shrimp yields as great per unit of expended energy as they intuitively seem? Or, is it possible that phyllopods contain certain micronutrients of human nutritional importance that transcend questions of optimality? Until these issues are addressed through further analysis of existing collections and additional field studies, questions regarding the specific role of phyllopods in the aboriginal diet of Great Basin native peoples through time will remain unanswered.

Hopefully, the results of this study will encourage others to explore the possibilities surrounding the use of phyllopods as a prehistoric food resource in other regions of the Great Ba-

sin. Research plans are currently underway to initiate subsurface excavations at the sites discussed above where positive results were obtained from artifacts, with special flotation analyses (zinc bromide and/or other light material flotation solutions) proposed for hearth features in the hope that carbonized phyllopod remains will be recovered. Such analyses, combined with additional immunological testing and paleofecal studies, may further enhance our understanding of this fascinating yet previously unrecognized prehistoric subsistence practice.

NOTES

1. LANDSAT image Path 40, Row 30, May 28, 1983, Scene ID Number 84031617491XO, on file at the Idaho Department of Water Resources, Boise.

2. A more recent, although preliminary, study (Yohe et al. 1998) suggested phyllopod exploitation on the Snake River Plain as early as 8,000 years ago. Two handstones reused as hammers recovered from Scaredy Cat Cave (10MA143) have tested positive for *Lepidurus* proteins. Each was recovered from strata dating from $6,680 \pm 80$ RCYBP to $8,190 \pm 100$ RCYBP. This lava tube site is close to several ephemeral ponds.

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REFERENCES

- Abbas, A. K., D. H. Lichtman, and J. S. Pober
1994 Cellular and Molecular Immunology. Philadelphia: W. B. Saunders and Co.
- Binford, Lewis R.
1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4-20.

- Cattaneo, C., K. Gelsthorpe, P. Phillips, and R. J. Sokol
 1992 Reliable Identification of Human Albumin in Ancient Bone Using ELISA and Monoclonal Antibodies. *American Journal of Physical Anthropology* 87(2):365-372.
- Chamberlin, Ralph V.
 1911 Ethno-botany of the Gosiute Indians of Utah. *Memoirs of the American Anthropological Association* 2(5):329-405.
- Creaser, E. P.
 1931 North American Phyllopods. *Science* 74: 1915.
- Culliford, B. J.
 1964 Precipitin Reactions in Forensic Problems. *Nature* 201:1092-1094.
- Daborn, Graham R.
 1977 The Life History of *Branchinecta mackini* Dexter (Crustacea: Anostraca) in an Argillotrophic Lake of Alberta. *Canadian Journal of Zoology* 55:161-168.
- Davis, Emma L.
 1965 An Ethnography of the Kuzedika Paiute of Mono Lake, Mono County, California. *University of Utah Anthropological Papers* No. 75.
- Dodson, Stanley I., and David G. Frey
 1991 Cladocera and Other Branchipods. In: *Ecology and Classification of North American Freshwater Invertebrates*, J. T. Thorpe and A. P. Covich, eds., pp. 723-786. San Diego: Academic Press.
- Druss, Claudia, and Mark Druss
 1982 Final Report: Class II Cultural Resources Inventory, Northside Pumping Division Extension, Idaho. Report on file at the Idaho State Preservation Office, Boise.
- Druss, Mark
 1989 Class III Cultural Resources Inventory, Wendell Land Exchange, Phase I. Report on file at the Idaho State Preservation Office, Boise.
- Druss, M., and S. Reale
 1989 Springtime on the Lava Plateau: Ephemeral Lakes and Subsistence-Settlement in South-Central Idaho. Paper presented at the 16th Conference annual meetings of the Idaho Archaeological Society, Boise.
- Eisele, J. A., Don D. Fowler, G. Haynes, and R. A. Lewis
 1995 Survival and Detection of Blood Residues on Stone Tools. *Antiquity* 69(262):36-46.
- Fiedel, Stuart
 1996 Blood from Stones? Some Methodological and Interpretive Problems in Blood Residue Analysis. *Journal of Archaeological Science* 23(1):139-147.
- Fowler, Catherine S., and Sven Liljeblad
 1986 Northern Paiute. In: *Handbook of North American Indians*, Vol. 11, Great Basin, Warren d'Azevedo, ed., pp. 435-465. Washington: Smithsonian Institution.
- Gould, Richard T., and Mark G. Plew
 1996 Prehistoric Salmon Fishing in the Northern Great Basin: Ecological Dynamics, Trade-offs, and Foraging Strategies. In: *Prehistoric Hunter-Gatherer Fishing Strategies*, Mark G. Plew, ed., pp. 64-83. Department of Anthropology, Boise State University.
- Grayson, Donald K.
 1993 *The Desert's Past: A Natural Prehistory of the Great Basin*. Washington: Smithsonian Institution.
- Gruhn, Ruth
 1961 The Archaeology of Wilson Butte Cave, South-Central Idaho. Pocatello: Occasional Papers of the Idaho State College Museum, No. 6.
- Henrikson, Lael Suzann
 1993 Class III Cultural Resource Inventory of the Potter Butte and Black Ridge Fire Rehabilitation Areas. Bureau of Land Management, Shoshone District, Reports of Investigations 93-1.
- Hyland, D. C., J. M. Tersak, J. M. Adovasio, and M. I. Siegal
 1990 Identification of the Species of Origin of Residual Blood on Lithic Material. *American Antiquity* 55(1):104-112.
- Johnstone, A., and R. Thorpe
 1982 *Immunochemistry in Practice*. London: Blackwell Scientific Publications.
- Kooyman, Brian, Margaret E. Newman, and Howard Ceri
 1992 Verifying the Reliability of Blood Residue Analysis on Archaeological Tools. *Journal of Archaeological Science* 19(3):265-269.
- Malouf, Carling
 1966 Ethnohistory in the Great Basin. In: *The Current Status of Anthropological Research in the Great Basin: 1964*, Warren L. d'Azevedo, Wilbur A. Davis, Don D.

- Fowler, and Wayne Suttles, eds., pp. 1-38. Reno: Desert Research Institute Technical Report Series, Social Sciences and Humanities Publication No. 1.
- Merriam, C. Hart
1955 *Studies of California Indians*. Berkeley: University of California Press.
- Miller, M. F. II, and R. W. G. Wyckoff
1968 *Proteins in Dinosaur Bones*. Proceedings of the National Academy of Science 60: 176-178.
- Morgan, Dale L.
1947 *The Great Salt Lake*. Indianapolis, IN: Bobbs-Merrill.
- Newman, Margaret E.
1990 *The Hidden Evidence from Hidden Cave, Nevada*. Ph.D. dissertation, University of Toronto.
- Pavesic, Max G., and William Studebaker
1993 *Backtracking: Ancient Art of Southern Idaho*. Pocatello: Idaho Museum of Natural History.
- Pennak, Robert
1989 *Fresh-water Invertebrates of the United States: Protozoa to Mollusca (3rd ed.)*. New York: John Wiley and Sons, Inc.
- Plew, Mark
1990 *Modelling Alternative Subsistence Strategies for the Middle Snake River*. *North American Archaeologist* 11(1):1-15.
- Prager, E. M., A. C. Wilson, J. M. Lowenstein, and V. M. Sarich
1980 *Mammoth Albumin*. *Science* 209:287-289.
- Reed, W. G., J. Ross, and B. L. Ringe
1986 *Archaeological Investigations on the Idaho National Engineering Laboratory, 1984 and 1985: A Report of Cultural Resource Inventory Projects (8 vols.)*. Swanson-Crabtree Anthropology Research Laboratory, Idaho State University, Pocatello.
- Robbins, L. L., and K. Brew
1990 *Proteins from the Organic Matrix of Core-Top and Fossil Planktonic Foraminifera*. *Geochimica et Cosmochimica Acta* 54: 2285-2292.
- Roop, William
1984 *The Archaeology of Vernal Pools: An Example from Placer County*. In *Vernal Pools and Intermittent Streams*, S. Jain and P. Moyle, eds., pp. 9-17. University of California, Davis, Institute of Ecology, Publication No. 28.
- Royal Canadian Mounted Police
1983 *Methods Manual, Serology Section*. Ottawa, Ontario.
- Schneider, Joan S.
1996 *Freshwater Shrimp in Playa Environments in the Mojave Desert: Implications for Archaeologists*. Paper presented at the annual meetings of the Kelso Conference on the Prehistory of the California Deserts, Red Rock Canyon State Park, California.
- Scott, D. A., Margaret E. Newman, M. Schilling, M. Derrick, and H. P. Khanjian
1996 *Blood as a Binding Medium in a Chumash Indian Pigment Cake*. *Archaeometry* 38(1):103-112.
- Shimkin, Demetri B.
1986 *The Introduction of the Horse*. In: *Handbook of North American Indians, Vol. 11, Great Basin*, Warren d'Azevedo, ed., pp. 517-524. Washington: Smithsonian Institution.
- Steward, Julian H.
1933 *Ethnography of the Owens Valley Paiute*. University of California Publications in American Archaeology and Ethnology 33(3).
1938 *Basin-Plateau Aboriginal Sociopolitical Groups*. Bureau of American Ethnology Bulletin 38.
- Sutton, Mark Q.
1988 *Insects as Food: Aboriginal Entomophagy in the Great Basin*. Ballena Press Anthropological Papers No. 33.
1995 *Archaeological Aspects of Insect Use*. *Journal of Archaeological Method and Theory* 2(3):253-298.
- Thomas, David H.
1983 *The Archaeology of Monitor Valley 1, Epistemology*. *American Museum of Natural History Anthropological Papers* 58(1).
- Thorpe, James H., and Alan P. Covich, eds.
1991 *Ecology and the Classification of North American Freshwater Vertebrates*. San Diego: Academic Press.
- Voss-Foucart, M. F.
1968 *Paleoproteins des Coquilles Fossiles d'Oeufs de Dinosaures du Cretace Superieur*. *Journal of Paleontology* 42(1):1-12.

rior de Provence. *Comparative Biochemistry and Physiology* 24:31-36.

Warren, Claude N., Joan S. Schneider, Diane Lynn Winslow, Jeff Wedding, and Hal Rager

1996 On the Shores of Silver Lake: Aboriginal Shoreline Features and Functional Hypotheses. Paper presented at the Great Basin Anthropological Conference, Kings Beach, California.

Yohe, Robert M. II

1987 Phylloponds as a Possible Aboriginal Food Resource in the Mojave Desert. Paper presented at the seventh annual James C. Young Colloquium, University of California, Riverside.

Yohe, Robert M. II, Margaret E. Newman, and Joan S. Schneider

1991 Immunological Identification of Small-

Mammal Proteins on Aboriginal Milling Equipment. *American Antiquity* 56(4): 659-666.

Yohe, Robert M. II, Lael Suzann Henrikson, Margaret E. Newman, and Mark Druss

1998 Prehistoric Phyllopod Exploitation on the Snake River Plain. Paper presented at the 21st annual conference of the Society of Ethnobiology, Reno, Nevada.

Yohe, Robert M. II, Margaret E. Newman, Mark Q. Sutton, and Joan S. Schneider

1992 Protein Residue Analysis of Ground Stone Artifacts: New Results from Five Archaeological Sites in Southern California. Paper presented at the annual meetings of the Society for California Archaeology, Pasadena.

