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Further Experimental Evaluation of the Function of Pitted Stones on the Central California Coast

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An experiment reported by Cook et al. (2017) demonstrated that there was a strong morphological similarity between a stone used to crack open California sea mussels and archaeological pitted stones. Based on these findings, the authors concluded that the primary function of pitted stones was to process mussels. The use of pitted stones to crack open turban snails was also suspected but was not evaluated experimentally. Here we report the results of an experiment in which we processed 572 turban snails using two flat, fist-sized cobbles, one as a hammer and the other as an anvil. As in the Cook et al. (2017) study, we found that cracking open these mollusks also produced a pitted morphology on the anvil stone virtually identical to that of archaeological pitted stones. From this, we conclude that pitted stones were almost certainly used to crack open turban snails as well as mussels along the central coast of California.

In 2017 Cook et al. reported the results of a multi-faceted evaluation of the function of pitted stones, a simple but ubiquitous artifact found in great numbers at coastal sites in central and southern California. Also known as dimple stones, pitted hammerstones, acorn crackers, acorn anvils, and/or pitted anvils, the pitted stone's function had long been uncertain, although Wallace suggested as early as 1954 that it was used to smash open mollusks. Breschini and Haversat (1988:47, 1989:69) suggested that pitted stones were generic, multifunctional tools used to exploit and process a variety of marine resources, while Strudwick (1995) suggested that they were used specifically to process turban snails (*Chlorostoma* spp.).

Important preliminary experimental work on turban snail processing and/or pitted stones was reported by

Cook et al. (2017), Ferneau (1998), Jones and Ferneau (2002), Rabb (1992), Raab and Yatsco (1992), and Strudwick (1995). Raab (1992:77) noted that turban snails dominated many middens on San Clemente Island, and that the snail shells were almost always broken and not burned (Raab and Yatsco 1992:183). Raab and Yatsco surmised from this that turban snails were crushed and boiled to make some type of soup. They tested this hypothesis by collecting and boiling 65 turban snails for ten minutes, and then removing the meat from each shell individually. This led them to the conclusion that it would be more efficient to crush the shells in bulk rather than removing the meat from each of them, one at a time. Strudwick (1995) connected the processing method envisioned by Raab with pitted stones, suggesting that the latter was an artifactual product of the former. He then conducted an experiment, similar to the one we report here, using a volcanic cobble to crush 30 raw turban snails. He found that the cobble began to show the beginning of a pit after 30 snails were processed. Ferneau (1998) conducted another experiment in which she collected 476 turban snails (20 minutes collecting time) and boiled them for 15 minutes. As Raab (1992) noted, Ferneau (1988) found that the turban snail does separate itself from the shell upon boiling, which leaves two options for recovering the meat: "picking" (using a sharp object like a toothpick to stab the meat and pull it out) or "crushing." She found the picking method to be more time-consuming, making the net post-encounter caloric return from crushing (102.8 Kcal/hr.) higher than that from picking (69.4 Kcal/hr.; Table 1). This suggests that greater efficiency could be achieved in the exploitation of turban snails by crushing or smashing them open.

Ferneau also quantified the amount of broken versus whole shell recovered in midden samples from two archaeological sites, CA-SLO-179 and -267. She found that whole shells represented between 3.3% and 7.7% of the recovered turban snail shell, supporting the qualitative observations made by Raab (1992) and Strudwick (1995) about the relative proportion of broken versus whole shells in middens on San Clemente Island. This further reinforced the likelihood that the snails were processed by smashing or crushing the shells to extract the meat.

Cook et al. (2017) examined the spatial distribution of pitted stones and found that they tend to occur along rocky coasts at locations with high frequencies of California

Table 1
RESULTS OF TURBAN SNAIL COLLECTION AND PROCESSING EXPERIMENTS

Study	Collection Time (Minutes)	Processing Method	Processing Time (minutes)	n	Shell weight (g.)	Meat weight (g.)	Kcal ^a	Post Encounter (processing labor only) Kcal/hr.	Total Kcal/hr. (combined collection and processing time)
Ferneau (1998)	15	Picking ^b	120	351	471.2	131.4	156.1	78.1	69.4
Ferneau (1998)	5	Crushing ^b	35	125	291	58	68.9	118.8	102.8
Webb herein	20	Crushing ^c	151	572	1,900	600	712.8	284.8	250.1

^aBased on bomb calorimeter data reported herein provided by University of Arkansas of 1.188 Kcal/gm.

^bPreceded by boiling

^cUncooked meat

mussels (*Mytilus californianus*) and turban snails. Based on this pattern, they developed a working hypothesis that pitted stones were used primarily to process mussels. They then conducted an experiment in which 303 California sea mussels were cracked open using one small flat cobble as an anvil and another as a hammer. The experiment demonstrated that there was a strong similarity between the anvil stone used to process the mussels and archaeological pitted stones. Based on these results, Cook et al. (2017) concluded that the primary function of pitted stones on the central coast was to process mussels and occasionally turban snails. However, the use of these stones in processing the latter was not evaluated experimentally. Here we report the results of a second experiment in which we processed turban snails.

EXPERIMENTAL METHODS

Collection

At low tide on December 7, 2017, the lead author was given access to exposed rocky shelves on the Pecho Coast in San Luis Obispo County, adjacent to the Diablo Canyon Nuclear Power Plant. He and an assistant spent 10 minutes picking turban snails off of intertidal rocks by hand and placing them into buckets (Fig. 1), without the use of any prying or cutting tools. Most of the snails were found congregated in large groups within small submerged crevices, often alongside California sea mussels (Fig. 2). Turban snails do not attach themselves permanently to rocks, so collecting them is simply a matter of plucking them individually (or several at a time) from rocks or rock crevices and putting them into a container. The lack of resistance from the turban



Figure 1. Jack Webb (top) and Madeline Noet collecting turban snails at low tide near the Diablo Canyon Nuclear Power Plant.



Figure 2. Close-up of rock face showing turban snails and mussels with trowel for scale.

snails makes their collection efficient and non-exertive, especially in comparison to mussels, which need to be wrenched from the rocks. The combined efforts of the two collectors yielded 572 turban snails (Fig. 3) after 20 minutes of total collection time. The snails were then transported to the California Polytechnic Archaeological Laboratory for processing.

Processing

The procedures used in processing the snails were similar to those employed in the mussel experiment reported by Cook et al. (2017) and the earlier turban snail experiment reported by Strudwick (1995). Two flat, unmodified cobbles, similar in size and shape to archaeological pitted stones, were obtained from Spooners Cove, within Montana de Oro State Park, 4.58 miles from the Diablo



Figure 3. Yields from experimental shellfish collection. The center bucket contains turban snails.

Canyon Nuclear Power Plant. The cobbles were selected to closely match the flat shape and size of the pitted stone artifacts found at coastal central California sites. As Cook et al. (2017) have pointed out, many sites in San Luis Obispo County that yield pitted stones in substantial numbers occur at the mouths of creeks, and the morphology of pitted stone artifacts typically shows that they were made from water-worn cobbles originating from creeks. The flattest of the two collected cobbles was selected to serve as the anvil and was placed on the ground. The second cobble was then designated as a hammerstone and was used to actually break open the turban snails. After some experimentation, it was recognized that the optimal technique for processing was to place the turban snail aperture down on the anvil and then use the face of the hammer to strike the side of the turban snails spire with moderate force. This resulted in a crack along the side of the turban snail shell. The face of the hammer was then used to strike the top or spire of the turban snail and crack the shell into multiple segments. If the correct force and technique were applied, the shell would split in a manner that allowed for the collection of the meat with minimal shell residue. One at a time, turban snails were placed on the anvil and smashed with the hammer (Fig. 4); the meat was then extracted and the shell pieces swept aside. Using this process, it took 2 hours and 31 minutes to process all 572 turban snails (Table 1). The snails produced 600 g. of edible flesh and 1,900 g. of broken shell.



Figure 4. The process of cracking open turban snails with an anvil and hammerstone. The pit develops on the anvil.

Caloric Evaluation

Although caloric evaluation was not a primary goal of the current study, a sample of turban snail meat was sent to the University of Arkansas for analysis via bomb calorimeter to quantify the potential subsistence value of this resource.

RESULTS

As in the earlier experiment conducted by Cook et al., the anvil stone used to crack open the turban snails developed a distinctive circular pit on one face (Fig. 5),



Figure 5. Experimental anvil after processing turban snails for one hour; the pit was clearly emerging at this point.

similar to those on both the anvil used in the mussel processing experiment and on archaeological pitted stones. In this instance, the pit produced from turban snail processing was 30.4 mm. in diameter and 5.8 mm. deep. This was larger than the pit resulting from the mussel processing (diameter: 21 mm., depth: 3.5 mm.), but is within the range documented in several large collections of pitted stones from San Luis Obispo County, and in a sample reported by Strudwick in his seminal 1995 paper (Table 2).

The bomb calorimeter analysis showed that one gram of turban snail meat represents 1.188 calories, which means that the total yield from the experiment represented 712.8 Kcal. When collection (20 minutes) and processing (151 minutes) times are figured in, the turban snails in this experiment produced 210.5 grams of meat/hour, and 250.1 Kcal./hour of net energy. Mussels, in comparison, have yielded between 116 and 682 grams of meat/hour (Cook et al. 2017; Jones and Richman 1995).

Table 2
SUMMARY DIMENSIONS OF PITTED STONES FROM SELECTED ARCHAEOLOGICAL COLLECTIONS

Site	N Pitted Stones	N Pits	Range Pit Diameter (mm.)	Mean pit width (mm.)	Range Pit Depth (mm.)	Mean Pit depth (mm.)	Reference
SLO-51/H	68	95	7.7-30.9	18	0.6-6.2	2	Jones et al. (2017)
SLO-58	43	64	13.4-34.2	21.2	1.3-8.4	3.7	Herein
SLO-175	15	25	16.1-33.6	22	1.0-6.0	2.5	Jones and Waugh (1995)
SLO-179	56	74	6.7-65.7	23.3	0.1-7.8	2.8	Jones and Ferneau (2002)
SLO-267	258	406	9.0-82.6	21.9	0.1-11.5	2.5	Jones and Ferneau (2002)
Mesa College Collection	21	42	12.0-41.0	22	0.0-5.0	–	Strudwick (1995)
Total	461	706	6.7-65.7	20	0.1-11.5	2.9	

CONCLUSION

Cook et al. (2017) provided compelling experimental evidence suggesting that archaeological pitted stones were used to process California sea mussels. They further suspected that turban snails were also processed with these stones, but they did not evaluate that function experimentally, although Strudwick (1995) had provided some preliminary experimental support for the hypothesis. Here we provide additional experimental evidence that bolsters Strudwick’s hypothesis. As with the mussel processing experiment, cracking open turban snails with cobbles, using one as an anvil and another as a hammer, produced a distinctive dimple or pit on the face of the anvil stone that was nearly identical to those found on archaeological pitted stones (Fig. 6). We conclude from this that the processing of turban snails was equally likely to contribute to the morphology of the pitted stones found archaeologically, and that the processing of turban snails and mussels was probably their primary function on the central coast of California. Furthermore, we suspect that both species of shellfish were collected concurrently and somewhat indiscriminately by native foragers, since the two are found together on exposed rocks at low tide. While mussels were likely the preferred target since they are larger and yield more edible meat, turban snails could be readily scooped up at the same time that mussels were being plucked. As both Ferneau (1998) and Strudwick (1995) discovered, boiling turban snails does not necessarily release the snail from the shell; thus, the meat has to be extracted either by being picked out or



Figure 6. Comparison of the anvil used in processing turban snails (left), the anvil used to process 303 mussels (center), and a typical archaeological pitted stone from CA-SLO-58 (right).

by the shells being crushed. Both the current experiment and Ferneau’s (1998) earlier research have shown that the latter method is considerably more efficient. This would be particularly true in the preparation of the shellfish for use in soups, stews, or gruels, which are types of foods frequently referred to in ethnographic accounts from California (see discussion in Cook et al. 2017). As suggested by Cook et al. (2017), Rabb (1992), and Strudwick (1995), pitted stones on the central and southern California coasts were probably used to process both turban snails and mussels in bulk for consumption in gruels or stews. However, neither we nor Cook et al. claim that this was necessarily the sole function of this implement at all locations.

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