Zooarchaeology of Hacienda El Progreso, San Cristóbal, Ecuador

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A large collection of archaeofaunal specimens was recovered from excavation units in the historic Hacienda El Progreso during 2014 and 2015. Specimens were cleaned with light brushing in water, dried, and rebagged in El Progreso, prior to their identification and analysis in the terrestrial ecology laboratory of the Galápagos Science Center, where they were subsequently stored. Preserved specimens were recovered from almost every excavation unit (Table 1), and by number, weight, and volume comprise the largest single artifact category

Área	Unidades con Huesos	Número	Pesa (g)
Carpintero	1,2,3	23,025	109,451
Cobos	5,6,7,8,9	277	1245
Carcel	1,2	73	118
Camal	10, 11, 12	2,117	8006

Table 1 El Progreso Archaeological Units with Recovered Archaeofaunal Specimens

collected by the project. A total of 25,492 specimens (118,820 g) are tabulated in database files (Paradox), according to: Unit, Level, Quantity, Weight, Identification, Size (S,M,L), Element, Portion, Side, Differential Preservation in quartiles of Scan Sites where applicable, Dentition Present, Fusion/Eruption, Heat Modification, Surface Modification, Breakage, and Comments. Various standardized measurements of weight-bearing bones of large mammals, and maxillae of fish were also recorded. The data are accessible in four separate files for each site, and one combined file for the entire project. The entire faunal assemblage is summarized in Table 2.

El Progreso Faunas	**Nombre Común/Common Name**	**Freq.**	**0.00g**
Indeterminate	Indeterminado/Indeterminate	37	26.00
Anthozoa	Coral/Coral	1	3.00
Eucidaris	Erizo Lapidero/ Pencil Urchin	24	7.00
Chiton goodalli	Quitón Gigante/Giant Chiton	1290	2627.00
Chiton sulcatus	Quitón Tallado/Sculptured Chiton	166	196.00
Mollusca	Molusco/Mollusc	36	44.00
Gastropoda	Gastrópodo/Gastropod	2	2.00
Tornatellides cf. *chathamensis*	Caracól de Arbol/Tree Snail	1	0.00
Subulina cf. *octona*	Caracól/Miniature Awlsnail	1	0.00
Bulla	Caracol Burbuja/Bubble Snail	2	5.00
Cancellaria gemmulata	Cancelaria Tallada/Sculptured Nutmeg	1	1.00
Cantharus sanguinolentus	Cantarus Sanguinolento/Sanguine Cantharus	1	2.00
Cerithium	Cerith/Pada	4	27.00
Cerithium gallapaginis	Pada de Galápagos/Galapagos Cerith	2	0.00
Conus	Cono/Cone	3	43.00
Conus nux	ConoNuez/Nut Cone	2	19.00
Cypraea albuginosa	Caurí Linares Blancos/White-spotted Cowrie	3	16.00
Hipponix grayanus	Casco Con Cuentas/Beaded Hoofshell	1	0.00
Plicopurpura	Púrpura/Purpura	3	66.00
Plicopurpura columellaris	Púrpura de Boca Pequeña/Small-Mouthed Purpura	1	39.00

Plicopurpura patula	Púrpura de Boca Ancha/Wide-Mouthed Purpura	3	106.00
Patellogastropoda	Lapa/Limpet	1	0.00
Fissurellidae	Fisurela/Key Hole Limpet	6	2.00
Fissurella	Fisurela/Key Hole Limpet	1	0.00
Lottiidae	Lapa/Limpet	9	1.00
Bivalvia	Bivalvo/Bivalve	2	0.00
Arcidae	Arca/Ark Clam	1	0.00
Papyridea aspersa	Barberecho Jaspeado/Clam	1	10.00
Lucinidae	Lucina/Lucine	1	0.00
Ctena	Lucina de Galápagos/Galapagos Lucine	1	1.00
Ostreidae	Ostra/Oyster	1	1.00
Pinctada	Madre Perla/ Panamanian Pearl Oyster	1	17.00
Pectinidae	Vieira/Scallop	1	4.00
Osteichthyes	Peces/Bony Fish	1682	1089.00
Serranidae	Bacalao/Grouper	1174	2481.00
Reptilia	Reptil/Reptile	9	0.00
Cheloniidae	Tortuga Marina/Marine Turtle	774	5074.00
Iguanidae	Iguana/Iguana	20	13.00
Aves	Ave/Bird Indeterminate	37	8.00
Gallus	Gallina/Chicken	40	43.00
Mammalia	Mamífero/Mammal Indeterminate	18105	65538.00
Carnivora	Carnívoro/Carnivore	36	13.00
Canis	Perro/Dog	66	179.00
Felis	Gato/Cat	15	11.00
Artiodactyla	Ungulado de Dos Dedos/Two-Toed Ungulate	244	2322.00
Sus	Cerdo/Pig	65	363.00
Bovidae	Bóvido/Bovids	1	2.00
Capra	Cabra/Goat	234	1606.00
Bos	Res/Cow	1369	36838.00
Equus	Caballo/Horse	2	35.00
Rodentia	Roedor/Rodent	3	0.00
Rattus	Rata/Rat	5	0.00
Leporidae	Conejo/Rabbit	1	0.00

Table 2. Identified El Progreso Archaeofaunas, Common Names, Frequency, and Weight

Animal bones are ubiquitous in and around the area of the town site, and the contextual integrity of the shallow excavation units are questionable; therefore, our analyses are focused on the sealed deposits of the Carpintero midden located directly below the Cobos house site near the town entrance. These deposits appear as a lense of compact midden material almost one meter below surface, where artifactual associations date deposits directly to the focal years of the hacienda's early operations between 1879 and 1904. We suggest that this midden represents accumulated waste material from the house, and extractive efforts of the hacienda, through its location directly down slope from the Cobos house and in close proximity to the communal kitchen and eating area of the hacienda. The Carpintero collection includes 23,025 specimens (109,451 g) and is summarized in Table 3.

Sitio Carpintero	Nombre Común/Common Name	Freq.	0.00g
Indeterminate	Indeterminado/Indeterminate	37	26.00
Anthozoa	Coral/Coral	1	3.00
Eucidaris	Erizo Lapidero/ Pencil Urchin	13	4.00
Chiton goodalli	Quitón Gigante/Giant Chiton	535	1263.00
Chiton sulcatus	Quitón Tallado/Sculptured Chiton	53	77.00
Mollusca	Molusco/Mollusc	22	20.00
Bulla	Caracol Burbuja/Bubble Snail	2	5.00
Cantharus sanguinolentus	Cantarus Sanguinolento/Sanguine Cantharus	1	2.00
Cerithium	Cerith/Pada	4	27.00
Cerithium gallapaginis	Pada de Galápagos/Galapagos Cerith	2	0.00
Conus	Cono/Cone	2	32.00
Plicopurpura	Púrpura/Purpura	1	58.00
Plicopurpura patula	Púrpura de Boca Ancha/Wide-Mouthed Purpura	2	64.00
Patellogastropoda	Lapa/Limpet	1	0.00
Fissurellidae	Fisurela/Key Hole Limpet	6	2.00
Lottiidae	Lapa/Limpet	8	1.00
Bivalvia	Bivalvo/Bivalve	2	0.00
Arcidae	Arca/Ark Clam	1	0.00
Lucinidae	Lucina/Lucine	1	0.00
Ctena	Lucina de Galápagos/Galapagos Lucine	1	1.00
Ostreidae	Ostra/Oyster	1	1.00
Pinctada	Madre Perla/ Panamanian Pearl Oyster	1	17.00
Pectinidae	Vieira/Scallop	1	4.00
Osteichthyes	Peces/Bony Fish	1618	1070.00
Serranidae	Bacalao/Grouper	1146	2423.00
Reptilia	Reptil/Reptile	9	0.00
Cheloniidae	Tortuga Marina/Marine Turtle	766	5025.00
Iguanidae	Iguana/Iguana	18	8.00
Aves	Ave/Bird Indeterminate	35	8.00
Gallus	Gallina/Chicken	38	39.00
Mammalia	Mamífero/Mammal Indeterminate	16839	60963.00
Carnivora	Carnívoro/Carnivore	36	13.00
Canis	Perro/Dog	66	179.00
Felis	Gato/Cat	15	11.00
Artiodactyla	Ungulado de Dos Dedos/Two-Toed Ungulate	221	2118.00
Sus	Cerdo/Pig	26	161.00
Bovidae	Bóvido/Bovids	1	2.00
Capra	Cabra/Goat	221	1485.00
Bos	Res/Cow	1261	34304.00
Equus	Caballo/Horse	2	35.00
Rodentia	Roedor/Rodent	3	0.00
Rattus	Rata/Rat	5	0.00
Leporidae	Conejo/Rabbit	1	0.00

Table 3. Identified Carpintero Archaeofaunas, Common Names, Frequency, and Weight

The Carpintero archaeofaunas include a mixture of endemic wild faunas and introduced exotic domesticates, the latter comprising a significant proportion of specimens identified to the level of Order and lower, and tabulated by frequency, volume, and weight.

Exotic Domestic Faunas

The Carpintero archaeofaunal collection is heavily dominated by fragmented cow (*Bos Taurus*) bones and large artiodactyla specimens which most likely derive from cows as well. This summary of the cow specimens in the site assemblage is based upon both categories combined (n=1482). The Minimum Number of Individuals (MNI) represented in the sample is 27, based upon the Right Calcaneum sorted by context (MNI=29 disregarding context). Cow specimens are heavily fragmented; the only completely preserved specimens include various isolated teeth, carpals, tarsals, phalanges, and caudal vertebrae, all of which are relatively compact and dense specimens, as well as one complete lumbar vertebra, and one complete metacarpus. An impression of element representation in the assemblage is that most elements from the bovine skeleton are preserved. Exploration of skeletal representation within the assemblage is undertaken by comparing an expected number of preserved *cow* elements (MNI=27 X # in Skeleton) compared to the recovered Number of Identified Specimens (NISP) in the Carpintero midden. Figure 1 illustrates this relationship with the NISP value converted to a percentage of the expected value for clarity.

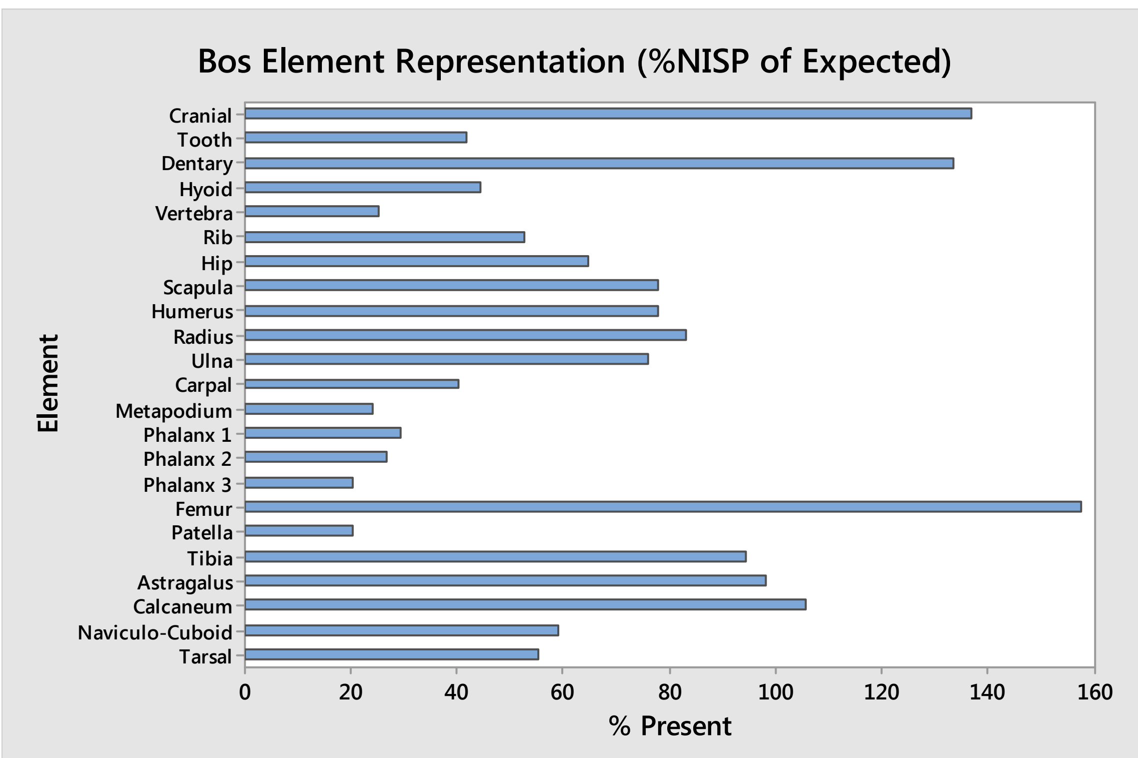

Figure 1. Expected Element Representation (MNI=27) Compared to Observed Representation (NISP as Percentage of Expected). Frequency data in Table 4.

Element	Expected Number of Elements (MNI=27)	Element NISP
Cranial	27	37
Tooth	810	340
Dentary	54	72
Hyoid	27	12
Vertebra	1404	358
Rib	756	398
Hip	54	35
Scapula	54	32
Humerus	54	42
Radius	54	45
Ulna	54	41
Carpal	324	131
Metapodium	108	26
Phalanx 1	108	32
Phalanx 2	108	29
Phalanx 3	108	22
Femur	54	85
Patella	54	11
Tibia	54	51
Astragalus	54	53
Calcaneum	54	57
Naviculo-Cuboid	54	32
Tarsal	54	30

Table 4. Raw counts for Figure 1. (includes *Bos*, L. Artiodactyla, L. Mammalia specimens) Expected Number of elements (#in skeleton X MNI=27 based on calcaneum). $r_s = 0.922$ p = 0.000

Elements from the entire cow skeleton appear to have preserved in the Carpintero midden in different proportions, with some greater than expected, and others less than expected. Survivorship of specimens in the Carpintero assemblage does not appear to be related to density (Fig.2), nor is it mediated by relative density in the other excavation units at the Cobos house site, and at the Camal and Carcel locations (Fig.3). The relationships between specimen survivorship and bone density in the Carpintero midden (Fig.2), and the other excavation areas (Fig.3), are both statistically weak and insignificant. A comparison of preserved limb specimens (*Bos*, L. Artiodactyla, and L. Mammal Limb Bone MNE) to bison fat content in long bones (Brink 1997)also suggests that there is no significant correlation with bovine limb survivorship and either %fat (r_s= .224 p=.421), or mean fat weight (r_s =.170 p=.638). Nor is there any significant correlation with absent limb portions (MNEs) when adjusted for expected MNI (r_s = -.319, p=.247). The midden sample of cow bones appears to be composed of preserved skeletal elements from the entire body, suggesting that the sample represents local slaughtering of animals and disposal of all subsequently consumed portions in the Carpintero midden.

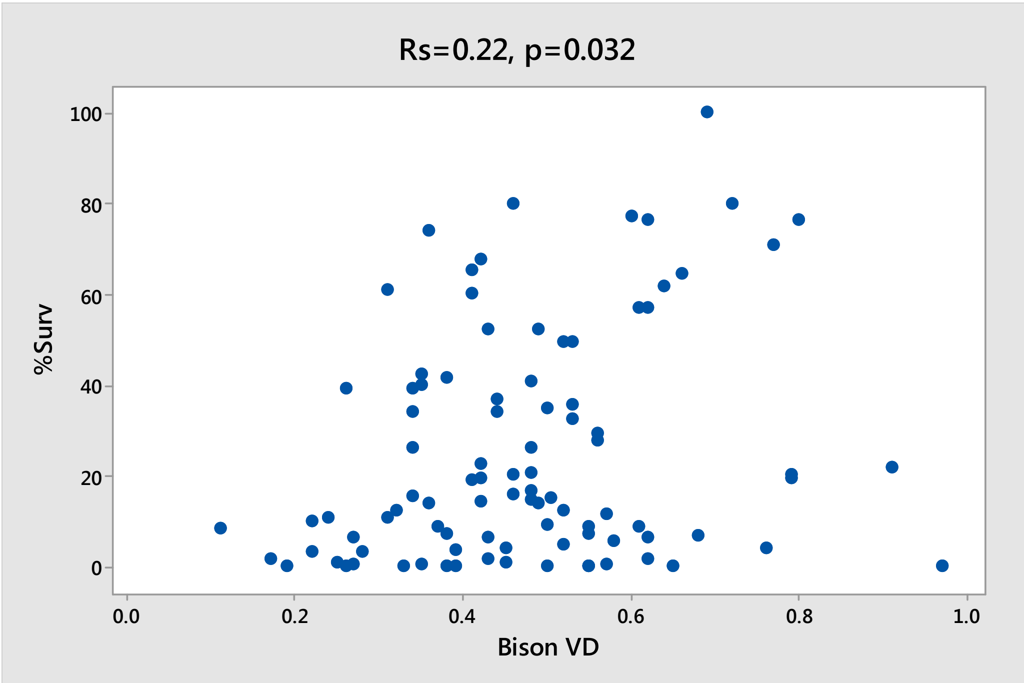

Figure 2. Relationship between %Survivorship and Bison VD values (Kreutzer 1992) in the Carpintero Midden

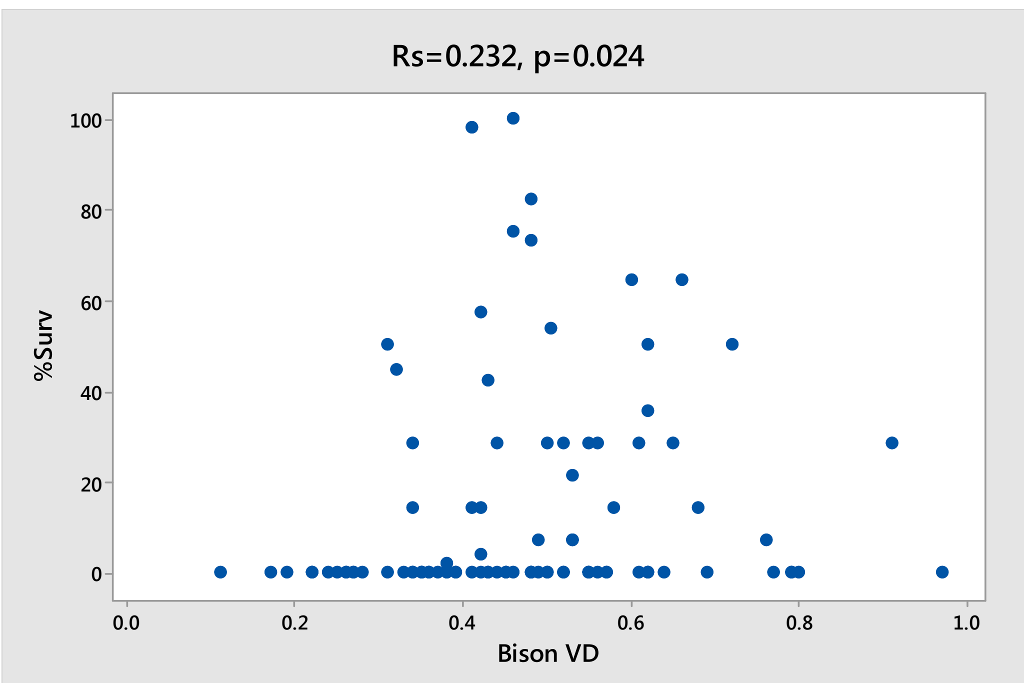

Figure 3. Relationship between %Survivorship and Bison VD values (Kreutzer 1992) in the other excavation units.

Standard measurements were recorded on the lower, primarily hind limb, weight-bearing elements, whenever possible. These were compared with dimensions recorded by Reitz and Ruff (1994) for early historic cattle in the New World. They divided early colonial cattle into two groups based on size: 1. Smaller English and American cattle from later periods in the north, and 2. Larger Spanish cattle from earlier periods in the south. An initial impression suggests that the El Progreso cattle fall clearly into their smaller category. This is borne out in comparisons of t-test scores (95%) applied to measurements of El Progress cattle: AST Bd (Group1), AST GLm (Group1-3), AST Dm (Group 1), AST GLl (Group1-3), AST Dl (Group1-2), CALC GL (Group1-2), N-C GB (Group1-2), MC Bp (Group1-4) MT Bp (Group 1-3), and Tibia Bd (Group1-4). It is possible that the preserved *Bos* specimens in the assemblage represent smaller females. This would make sense, as historic records from Hacienda El Progreso suggest that wild cows were rounded up and penned for subsequent mating with captured and subsequently released bulls. It is also possible that the measured specimens in the assemblage are comprised of smaller castrates.

The supporting data are limited and admittedly weak; however, at least some female *Bos* specimens were preserved in the assemblage. Higham and Message (1970) use measurements from the complete metacarpus (Bd/GL X 100) for sex determination. Measurements obtained from one complete metacarpus in the collection ([57.93/205]X100 = 28.3) suggest an individual: 1. at the lowest end of the Russian Kalmyk bovine female ratio; 2. smaller than a Red Danish female; and, 3. within the range of an Aberdeen Angus female. This ratio is used because the GL alone overlaps between males and females, and Bd is considered dimorphic. An examination of the other metapodium Bd measurements (52, 56, 64.7 mm) in the Carpintero faunas (it is difficult to distinguish Distal MC from MT) all lie within Kalmyk female and Aberdeen Angus female ranges, and are still smaller than Red Danish females. Limited data therefore suggest that they are not male, and are also relatively small. Following Chaplin (1971:168) the ratio of 28.3 also falls below the minimum size for castrated male oxen. The metapodial Bd interpretation of females is also corroborated by measurements from Fock's (1966) dissertation data in Grigson (1982:8, Fig. 2). The corresponding measurements for cows range from 62-71 mm (Mean=67mm, SD 65-69), so the few Carpintero *Bos* measurements do not overlap at all with steers or bulls, and are at the lowest end of the range for Fock's Schwarzbuntes breed.

The identification of relatively small cattle in the Carpintero assemblage is further corroborated by estimating Withers Height (WH), Body Length (BL) and weight. The single, complete metacarpal specimen in the assemblage can be evaluated using criteria developed by Matolsci (1970): 1. WH (MC GL X coefficient of 6.03 female, 6.33 male, 6.18 avg) 205 X 6.03=1236 mm or 48.7"; 205 X 6.18 = 1266.9 or 49.9". 2. Body Length ([WH X100]/shape index male of 79.2 for a Simmentaler male, 85.4 for a Jersey male, and 73.1 for females). As both are smaller breeds, an average female value of 79.2, results in 1266.9 X100 /79.2 = 1599.6 mm or 63" 3. Body weight using Hungarian Longhorn measurements (quantitative value of MC 1562 male, 1326 female) (k =constant value, Cow MC 1.000, male 1.055 –medium nutritional weight) is calculated: ([MC weight (g)/quantitative value] X [Avg. MC length/real MC length]) X K)^2 X 1000 =kg, or [159/1326 X 205/205 X 1.000]^2 = 143.4 kg, 315.5 lb female (but can be as little as 115 kg or 253 lbs). The admittedly limited available data suggests that at least one of the cows represented in the Carpintero midden was quite small, measuring just over 4 feet at the shoulder (WS), a little over 5 feet in body length (BL) and weighing a maximum of 315 lbs.

These tentative data can be used to compare how the Carpintero specimens conform with known breeds. Noddle (1973) uses astragalus measurements involving a multiple (GLl X GLm X Bd), which can be compared to UK breed weights in which fat has been removed. The averaged measurements from the complete astragali (n=18) in the Carpintero assemblage (4.17 X 6.57 X 6.1 = 167.2) generate a multiple that roughly compares with a female Hereford X Angus cross at 161.8 kg or 356 lbs. The largest complete astragalus in the Carpintero collection (7.02 X 6.78 X 4.78 =227.5 generates a multiple that roughly compares to South Devon castrates weighing 175 kg (385 lbs), a North Devon weighing 175.9 kg (387 lbs) and an Angus weighing 228 kg (502 lbs). The smallest complete astragalus (6.26 X 5.9 X 4.1 = 151.9) is much smaller than any cattle studied by Noddle (1973). Other lower limb elements corroborate the small size of the Carpintero cattle. A comparison of the El Progreso cattle metrics with Higham's (1969) figures for Red Danish (larger) and Aberdeen Angus (smaller) breeds include: Calcaneum GL (n=6, avg.=129 , range, 119-138) which is smaller than an Aberdeen Angus female (134±5.15) Gb (n=1, 43.18) which is smaller than an Aberdeen Angus female (46±3.33); Astragalus GL (n=18, avg. = 65.729, range, 61.5-71.9) which is smaller than, but in the lower range of, an Aberdeen Angus female (69.1±3.12); Naviculo-Cuboid Gb (n-16, avg. = 55.865, range, 50.6-64.5) which is comparable to an Aberdeen Angus female (57.8±3.49), yet the biggest specimen is still smaller than Aberdeen Angus male; and, pooled 1st Phalanges Bp (n=8, avg.= 29.45, range, 26-35.6) less than an Aberdeen Angus female, GLpe (n=8, avg. = 62.46, range, 59.36-67.2) which is equivalent to an Aberdeen Angus female (61.8±3). In sum, the cattle from El Progreso, represented by preserved specimens in the Carpintero midden are very small cows.

It is likely that the relatively small cattle of El Progreso were related to the nondescript Criollo landrace, an often tan colored bovine with short, fine hair, barrel-shaped body, and upswept horns. Before the introduction of foreign breeding stock in the later nineteenth century, all Criollo cattle can be traced to a small population of cattle introduced by Columbus (Rouse 1977). Anadalusian cattle were introduced into the Canary Islands after 1479, from where they were first introduced into the Americas as early as Columbus' second voyage, after which the foundation herd established on Hispaniola by 1512 served as the source for breeding stock (Rouse 1977). Sponenberg (1992) suspects that fewer than 300 cattle were initially introduced, yet rapidly expanded in a novel, environment free of parasites and disease. Rodero et al. (1992:398) suggest that the original Criollo cattle shipped from the Canary Islands shared similarities with Anadalusian Retinta and Barrenda breeds. Recent studies suggest that genetic signatures of Iberian ancestry retained in Criollo cattle reflect low levels of gene flow and some reproductive isolation (Martínez et al. 2012). The proximate source for cattle originally introduced into northwestern South America was in Panama where the first breeding herd was established as early as 1510 with cattle from Jamaica and Hispaniola. Cattle were eventually brought from the Darién into northwestern Colombia by 1524, and after the establishment of Guayaquil in 1535, cattle were shipped from Panama for its founding herds, which remained unmixed with other cattle until the later nineteenth century (Rouse 1977).Today, the feral Galapagueño cattle are considered one of seven biotypes of the Ecuador Criollo. These can be relatively small, like the Jaspeado Manabita with an average WH of 128 cm or 50.4" and weight of 389 kg or 857.6 lbs (Porter et al. 2016:173). Although according well in WH, the El Progreso cattle are much smaller in weight. Having been introduced no earlier than the 1830s, it is doubtful that this can be attributed to island dwarfism. It is possible that the original founder population was selected for their smaller size, as they had to be shipped nearly 1000 km to the island. Webster's (1904:11) comment that Cobos had planned to breed local stock with Durban cattle, is probably a confused reference to Durham cattle. The Durham or Shorthorn was originally developed for dual use in northeastern England during the late eighteenth century, and was used in South America to upgrade local stock (Rouse 1970:312-315).

Cattle were transformed at El Progreso into exportable commodities, primarily as hides, oils, and salted meat, as well as food for local consumption. The age at death of some cattle in the Carpintero assemblage could be estimated, based upon skeletal maturation and dental wear. A total of 82 *Bos* elements in the recovered Carpintero assemblage are unfused, and various epiphyseal fusion schedules have been published (Grigson 1982; Habermehl 1961; Silver 1970). The unfused Carpintero cow bones are summarized in Table 5. Added to these age at death estimations are the later vertebral fusion dates published in Habermehl (1961:95) for slaughtered calves and cattle: Thoracic (NISP= 13, (<8yrs), Lumbar (NISP=6, <2-2.5 yrs), and Cervical (NISP=6, <8 yrs). Based upon MNI calculation from the calcanea (MNI=27), at least 12 of the 27 cattle potentially represented in the assemblage were slaughtered between 3-4 yrs, and of these at least four were slaughtered potentially as early as 2 years.

Element	NISP	MNI	Unfused	Age at Death (yrs)
Calcaneum	18	12	Tuber Calcis	3-3.5
Distal Femur	5	3	Epiphysis	3.5
Proximal Femur	15	4	Epiphysis	3.5-4
Proximal Humerus	3	3	Epiphysis	3.5-4
Distal Metapodium	10	10	Epiphysis	2-3 (averaged)
Distal Radius	10	7	Epiphysis	3.5-4
Distal Tibia	8	4	Epiphysis	2-4
Proximal Tibia	6	4	Epiphysis	3.5-4
Proximal Ulna	7	3	Epiphysis	3.5-4

Table 5. Age at Death Estimations from Skeletal Fusion for Carpintero cattle

Dental eruption schedules (Grigson 1982:21 Appendix 2; Silver 1970) for dentary specimens in the assemblage suggest slaughter of: 1. three individuals by the age of 4-5 yrs using nineteenth century data, or 2 yrs using commercial data; 2. one individual by 1.5 yrs or 2.5 yrs; and, 3. four individuals possibly as early as 1.5 yrs or 2.5 yrs. Tooth Wear Stages (TWS) were arbitrarily assigned for *Bos* premolars and molars following Grant (1982). It is difficult to suggest anything other than a relative sense of dental attrition related to wear from these data; many of these animals may have been feral, yet all subsisted on relatively open pasture forage. Carpintero TWS ranged from "a" (no dentine exposure) to "n" (extreme attrition). Mandible Wear Stages (MWS, or scored values for TWS) were assigned to three dentary specimens with more than 1 insitu cheek tooth (four specimens in the assemblage were preserved with only 1 cheektooth each which affords too great a range of error). These values are 16, 19 (similar in age to each other) and 27. A number of in-situ M_3 which erupt between 4-5 yrs have extensive attrition (TWS b NISP=2, c NISP=3, d NISP=2, e NISP=2, f NISP=1, g NISP=2, I NISP=1) suggesting that some old cattle were included in the death assemblage, due to varying, and at times extreme, dental attrition on the last erupting molar. The earliest erupting M_1 (6-9 mos) has higher attrition; however, it is exposed longer through eruption at an earlier age (e NISP=2, f NISP=1, g NISP=1, j NISP=2, k NISP=2). Some isolated molars (a NISP=1, b NISP=1, c NISP=1, d NISP=1,e NISP=2, f NISP=3,g NISP=3,k NISP=1,m NISP=1, n NISP=1) show severe attrition. Combining these data with the fusion schedules (above), it can be suggested that cattle were slaughtered at varying ages at El Progreso, with almost half under the age of 4-5 yrs, and certainly others at more advanced ages.

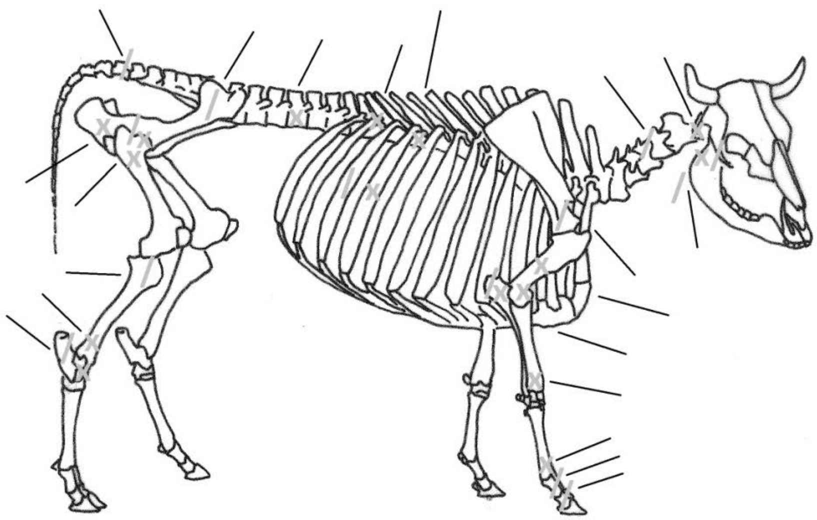

Figure 5. Cattle Butchery Modification: X=chop mark, /=cut mark

The highly fragmented assemblage of *Bos* combined with Large Artiodactyla specimens display surface modification visible as obvious butchery scars, often in the form of single and multiple cut marks, as well as chopping with a machete, or in certain cases, like larger articular ends, with a an axe-like cutting implement. Chop (X) and cut (/) mark locations (Fig. 4) are concentrated in various areas of the skeleton: 1: hyoid and ascending ramus of the dentary close to the articular condyles, possibly to remove the jaw, and also to access the tongue; 2. atlas to remove the head; 3. distal humerus and proximal ulna, possibly to disarticulate the lower from upper leg, perhaps after the entire front leg was easily detached from behind the scapula); 4. Phalanges with multiple cut marks possibly from skinning; 5. Proximal femur to remove the hind leg at the acetabulum of the hip; and, 6. lower tibia, calcaneum, and astragalus to remove the lower hind leg. It is interesting to note the dearth of metapodia and lower than expected frequencies of phalanges in the midden. Butchery modification is also apparent on lumbar, thoracic and rib elements. Many unidentified Large Mammal rib specimens also exhibit butchery modification in the form of cut, chop, and saw marks especially below the rib head. Historic records emphasize the production of skins for export, thin sheets of sun-dried charqui, and rendered fats. This form of production took place on other islands as well. The El Progreso assemblage represents the osseus detritus from any local consumption, but probably the bulk was created through the production of export commodities eventually transported to the coast for shipment to the mainland.

Goat (*Capra hircus*) specimens were relatively common in the Carpintero assemblage (NISP = 221, MNI = 6, based on L. Distal Humerus). An impression of element representation is that most elements from the caprine skeleton are preserved in the assemblage. Skeletal representation within the assemblage was explored by comparing an expected number of preserved *Capra* element (MNI=6 X their number in the skeleton) against the NISP recovered in the Carpintero excavations. Figure 6 shows this relationship with the NISP value converted to a percentage of the expected value. It appears that elements from the entire *Capra* skeleton are preserved in the Carpintero midden but in different proportions, with some greater than expected, and others less than expected.

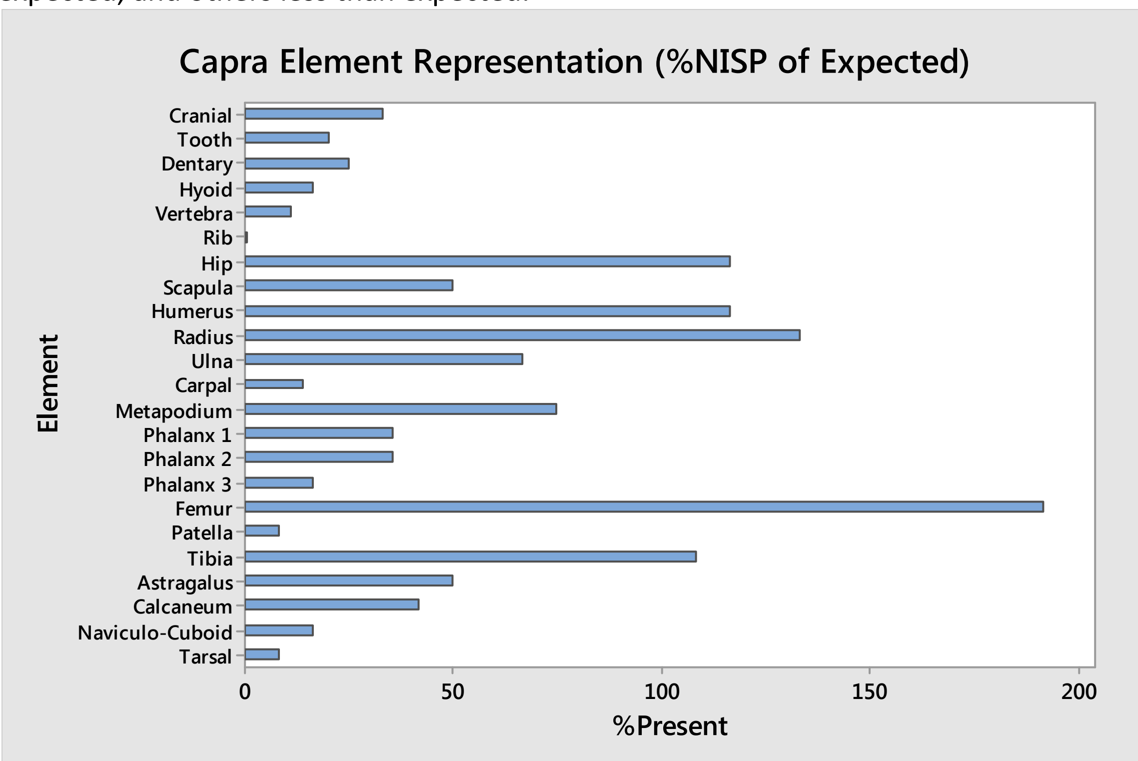

Figure 6. Expected Element Representation (MNI=6) Compared to Observed Representation (NISP as Percentage of Expected). Frequency data in Table 6.

Element	Capra NISP	Expected MNI=6
Cranial	2	6
Tooth	37	180
Dentary	3	12
Hyoid	1	6
Vertebra	35	312
Rib	1	168
Hip	14	12
Scapula	6	12

Humerus	14	12
Radius	16	12
Ulna	8	12
Carpal	10	72
Metapodium	18	24
Phalanx 1	17	48
Phalanx 2	17	48
Phalanx 3	8	48
Femur	23	12
Patella	1	12
Tibia	13	12
Astragalus	6	12
Calcaneum	5	12
Naviculo-Cuboid	2	12
Tarsal	1	12

Table 6. Raw counts for Figure 6. Expected Number of elements (#in skel X MNI=6 based on L. Distal Humerus). r_s = 0.51, p = 0.01

Possible WH is based on the correction formula suggested by Teichert (1975) for sheep (11.4). This estimation is based on a very small sample size of only two calcanea, which were the only complete bones in the collection of goat specimens. It is interesting, however, that they represent radically different sized goats: one fused calcaneum (GL = 85) yields a WH= 96.9 cm or 38"; and, the other fused calcaneum (GL = 53) yields a WH=60.4 cm or 23.8". The calcaneum and talus, according to Teichert, provide less reliable estimates than long bones, but have the advantage of not being less affected by sexual dimorphism in sheep (Davis 2000). Using estimates by (Kysely 2016), a WH of 63 cm and 69.5 cm might represent a goat of 40-45 kg and 50-55 kg in average body mass respectively. Better estimates are given by Vargas et al. (2007) for native Creole goat does from Mexico in which a HW=60.7±0.3 represents a mean weight of 26.6 kg which is quite similar to the smaller Carpintero goat specimen. The larger specimen is indeed very large, and one of tallest and largest goat breeds with a WH of 90/80 cm and weight of 140/110 kg is the Nubian which was disseminated by British steamers during the 1870s and 1890s (Porter et al. 2016:357-358). A complete, backward curving horn with a total length of 106 mm was recovered from the midden, which might be from a Nubian variety. Both males and females sprout horns and young males are reported to be able to grow horns 200-250 mm long in their first year.

Goats, like cows, were first introduced into the Americas during Columbus' second voyage in 1493, and today an estimated 36 million goats in Latin America and the Caribbean include as many as 28 native breeds broadly considered as Criollo (Ginja et al. 2017). However, unlike cows, goats along with sheep, pigs, and many dogs were already found in the Canary Islands, and it is presumed that they have at least some African roots (Rodero et al. 1992:388). Contemporary Criollo goats from Ecuador include the Criollo del Ecuador, and the partially feral Galápagos goat. The latter has the lowest genetic diversity amongst Criollo populations, due to a history of isolation, genetic drift, and inbreeding. Similar to the history for cows, goats were introduced during the early colonial period from Panama, with subsequent nineteenth century introduction of commercial breeds, particularly the Anglo-Nubian goat (Ginja et al. 2017). The latter were developed from old English goats crossed with lop-eared varieties from India, the eastern Mediterranean, and Africa. Earlier referred to as the Nubian, it was disseminated around the globe on P&O steamers which stocked them as shipboard food during the second part of the nineteenth century. They were often purchased from ships at ports-of-call for milk and meat. The large Anglo-Nubian, as it came to be called adapts easily to hot climates and is in global demand for cross-breeding (Porter et al. 2016:356-357).

Age at death estimations of Carpintero goat specimens suggest a range of differently aged individuals represented in the midden. Various specimens of an extremely young goat, based upon evidence in the form of unfused bones and limb bone shafts were recovered. Using Noddle's (1975) epiphyseal fusion estimations, at least one specimen died under the age of 12 months (scapula <12mos., Distal Humerus 12-13 months, and one unfused 2nd Phalange, >12 mos). Combined *Capra* and Medium Artiodactyla bones (NISP=260) include 67 unfused specimens. Using Habermehl's (1961) estimates for ossification of the vertebral centrae (48-60 months), all unfused specimens were from animals under five years of age at death, and based upon unfused Distal Radii and Distal Femora, at least three individuals (MNI=3 out of MNI=6 total) died under four years of age using Noddle's (1975) estimation for feral goats. Little additional information is provided by teeth: 1. two dentary specimens with erupted P_4 and M_1, and one maxilla with M^1 and M^2, may have possibly died between 35 and 48 months using estimates for feral goats (Bullock and Rackham 1982:77). One heavily worn upper molar preserved in alveolar bone showed TWS h, and one less worn TWS d, using published guides (Grant 1982). The possible age for the former could be minimally 5 years in age, and the latter minimally 2 years in age (Bullock and Rackham 1982:77).

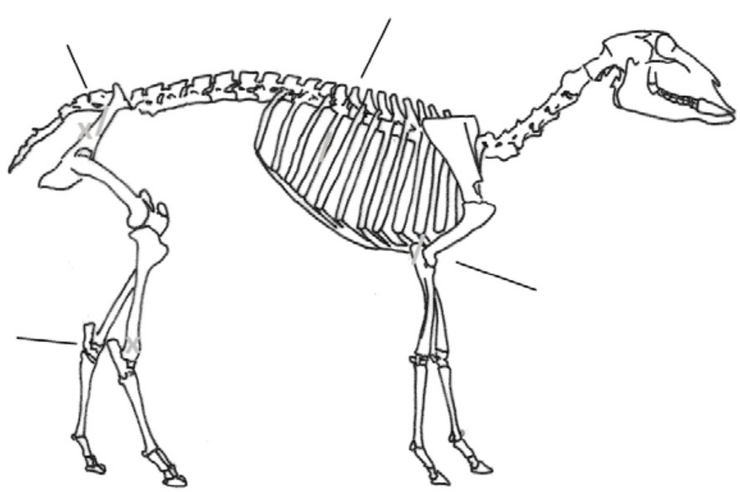

Figure 7. Goat Butchery Modification: X=chop mark, /=cut mark

Chop (X) and cut (/) mark locations on *Capra*, unidentified Medium Artiodactyla and unidentified Medium Mammal bones are located on the blade of the ilium, distal femur, proximal ulna, with various cut marks on unidentified Medium Mammal rib shafts (Fig. 7).

Over one half of the identified pig (*Sus scrofa*) specimens (NISP = 26, MNI = 3, based on right Maxilla) recovered from the Carpintero midden were either isolated teeth or tooth-bearing bones. What little can be interpreted from this collection, based upon a recently fused distal tibia, and an unfused metapodium suggests that at least some pigs were as young as two years at the time of their death (Bull and Payne 1982:66; Habermehl 1961:127). One erupting lower M_3 suggests that one individual may have been slaughtered between 1.5-3 years. One erupted lower molar in a dentary fragment with TWS c and an isolated molar with TWS d may indicate an age at death from 1.5-2 years. Like cows and goats, the Criollo pigs of South America are derived from early populations first introduced in 1493 during Columbus' second voyage, after which they often thrived as feral populations. Criollo pigs may have derived from Black and Red Extremaduran and Anadalusian varieties with additions from existing Canary Island populations which had possible African influence (Rodero et al. 1992:397). Recent genetic studies of Criollo pig populations indicate a complex phylogeny and an interestingly closer genetic relationship between Ecuadorian and Cuban Criollo pigs, which may indicate a genetic bottleneck after Cuba became an important distribution center during Conquest (Burgos-Paz et al. 2013; Revidatti et al. 2014).

Numerous dog (*Canis lupus familiaris*) bones (NISP = 66, MNI = 3) were recovered from the Carpintero midden. The majority of these bones (NISP = 53, 80%) were recovered from the same unit and level (U1 L.7), and most elements of the skeleton appear to have preserved. Some of the recovered specimens are from a very immature dog (one unfused Metatarsus: 5-6 months, and unfused hip bones: 6 months; Habermehl 1961:143). At least one of the dogs was a puppy, and other unfused bones (Proximal Humerus: 13 months, unfused vertebral central plates: 20-24 months, two right Distal Radii: 16-18 months; Habermehl 1961:143), indicate at least two immature dogs. One complete fused hip, and one complete dentary (GL 120 cm) are comparable in size to that of a mature beagle. One metacarpus may have been broken and re-healed. The limited sample may indicate the disposal of two puppies and one beagle-sized dog in the midden. A similar interpretation is suggested for domestic cats (*Felis catus*), represented by a few (NISP = 15, MNI = 2, complete right Humerus) specimens in the Carpintero midden. Two dentaries with erupted molars and no unfused epiphyses amongst the recovered limb bones indicate skeletally mature cats over 1 year in age at death (Habermehl 1961:151).

Two extremely worn equine cheek teeth include one complete pm^2 and one molar fragment from Unit 1 L.5 and Unit 2 L.4 respectively. They appear to represent at least one, likely old, horse. The horse was first reintroduced into the Americas during Columbus' second voyage in 1493, and by 1507 there was no need to send more mares for the breeding stock on Hispaniola. The horse was subsequently introduced into Puerto Rico and Jamaica in 1509, and then into Cuba by 1511 (Johnson 1943). The original horses may have varied in both quality and origin, and have entered Colombia from Panama (Colombian Paso Fino) and the eastern llanos

(Criollo de Vaquería), the latter a less selectively bred variety (Jiménez et al. 2012) which may have been similar to the early horse stock that found its way to Galápagos.

Hind limb elements, one upper incisor, and a hip fragment of a medium-sized rodent, most likely *Rattus* (NISP = 8, MNI = 2) were recovered in the midden. Both the smaller Black Rat (*R. rattus*) and larger Norway Rat (*R. norvegicus*) are found on most islands, but the Black Rat is most common and widespread. Endemic rodents are not found on San Cristóbal and where they are found in Galápagos, tend to be smaller than or in one case overlap in size with the smaller *R. rattus*. (Tirira 2007). One dentary of a rabbit was recovered from U1 L.1. Chicken (*Gallus gallus*) specimens were recovered from the Carpintero midden deposits (NISP=38, MNI=4 distal left Femur), with the majority concentrated in U1 L.7. Almost 80% of the identified Chicken specimens are elements from the legs and wings (Humerus NISP=7, Ulna NISP=6, Femur NISP=10, Tibiotarsus NISP=7).

Endemic Wild Faunas

Marine fish specimens constitute the second most abundant archaeofaunal category in the assemblage, next to cattle. The sample includes a large number of unidentifiable fish fragments (NISP=1618), and abundant specimens identified to the level of zoological Family (Serranidae or Sea Bass, Table 7) due to a lack of comparative material (NISP=1146, MNI=40, right Premaxilla). The composition of serranid elements appears to include almost equal numbers of cranial and post-cranial specimens (cranial NISP=600; postcranial NISP=546) representing elements from most of the skeleton. The recovered sample probably characterizes discarded skeletal detritus from whole fish that were transported from the coast to El Progreso. Many specimens indicate relatively large serranids, likely larger groupers (4 complete Maxillae: GL 95 mm, 97.4 mm, 105 mm, 106.1 mm). Employing the proportional measures published for Sailfin or Galápagos Grouper (*Mycteroperca olfax*) published by Smith (1971:207), a rough estimate of the size of groupers can be suggested based on these complete maxillae. If the latter represent 45% to 48% of overall head length, and standard body length can be estimated as between 2.6 and 2.9 times head length, then the smaller 95mm specimen may represent a 51.9cm to 57.9cm grouper, and the larger 106.1mm specimen may represent a grouper between 60.6 and 67.6 cm in length. These complete elements represent relatively large fish; nevertheless, Bacalao can attain total lengths upwards of 120cm (Table 7).

With the establishment of commercial fin-fishing in 1945, serranids comprised the bulk of the island's catch, and the Galápagos Grouper (*Mycteroperca olfax*) was the primary targeted species. In the years since, the larger apex-level groupers have declined dramatically in importance as local fisheries have increasingly been fishing down the marine food web. Today herbivorous mullets (Mugilidae) and coastal pelagic fish assume greater economic importance (Schiller et al. 2015).

Name	Length (cm)	Habitat, Depth, Substrate
Alphestes immaculatus Pacific Hamlet/Guaseta	30	demersal 1-50m; High relief, nocturnal
Anthias noeli Rosy Jewelfish/Pez Joya	29	184-351m; reef
Cephalophus panamensis Grayish Grouper/Enjambre	39	near-shore; 30-80m; rocky, reef
Cratinus agassizi Graery Threadfin Seabass/Plumero	60	shallow 1-12m, shallow, mangrove NT
Dermatolepis dermatolepis Leather Bass/Mero Cuero	100	21-40m, rocky shore, reef, often deep, diurnal
Diplectrum eumelum Dry Head Sandperch/Camotillo Cabezón	31	demersal 15-100m, sandy, mud
Diplectrum macropoma Mexican Sandperch/Serrano Mexicano	18	9-80m, sandy, mud
Diplectrum rostrum Bridled Sand Perch/Serrano Frenado	21	13-80m
Epinephelus analogus Spotted Cabrillo/Mero Orillero	114	-50m, rocky, juvenile-sandy
Epinephelus cifuentesi Olive Grouper/Norteño	100	40-120, rocky, reefs, lavashores, northern islands, 22.3kg, NT
Epinephelus labriformis Flag Cabrilla/Cabrilla Piedrera	>50	demersal, shallow-30m
Hemanthius peruanus Splittail Bass/Doncella	45	pelagic-neritic, 20-120m
Hemilutjanus macrophthalmos Grey-eye See Bass/Ojo de Uva	50	pelagic-neritic, 10-55m, vertical drop-offs, rocky, sandy DD
Hyporthodus mystacinus Misty Grouper/Mero	160	bathydemersal, 30-400m, rock outcrops, sandy, 107 kg
Liopropoma fasciatum Rainbow Basslet/Merito Arco Iris	18	24-250m, steep slopes, reefs
Liopropoma longleis Scalyfin Basslet		120-250m, reef associated
Myctoperca olfax Sailfin Grouper/Bacalao	120	open waters, vertical walls, juveniles shallow, VU
Myctoperca xenarcha Broomtail Grouper	150	demersal, 0-60m, 91kg
Paralabrax albomaculatus Whitespotted Sand Bass/Camotillo	50	cold waters, 10-75m
Paranthias colonus Pacific Creolefish/Gringo	35	10-70m, above reefs, diurnal
Pronotgrammus multifasciatus Threadfin Bass	28	40-200m, rough bottom, reef
Rypticus bicolor Cortez Soapfish/Jabonero de Cortés	19	3-68m, nocturnal, deep crevices
Serranus aequidens Deepwater Serrano	20	demersal, -205m
Serranus psittacinus Barred Serrano/Guaseta Serrano	18	6-61m, rock-reef-sand interface
Serranus stilbostigma Sideblotch Bass/Guaseta Manchada	15	-82m DD

Table 7. Indigenous and Endemic Galápagos Serranidae
Sources: CDF Galápagos Species Checklist; www. darwinfoundation.org Fishbase; www.fishbase.ca
NT=Near Threatened, DD=Data Deficient, VU=Vulnerable

A considerable bulk of the Carpintero archaeofaunal assemblage consisted of Cheloniidae (marine turtle) specimens (NISP=766). The majority of the sample includes shell fragments (NISP=690, 90% carapace/plastron specimens) which render inaccurate MNI estimations, although a very conservative estimate (MNI=3) based on sided limb elements is indicated. Green Turtles (*Chelonia mydas*) are commonly found in their adult form in the coastal waters off of San Cristóbal Island. Comparative osteological identification was further confirmed through aDNA analyses of four bone samples submitted to the Simon Fraser Ancient DNA Laboratory (DNA 1: proximal humerus and shaft, U1 L.7; DNA 2: Pleural fragment, U2 L.5;

DNA 3: complete Hyoid U2 L.5; DNA 4: distal Phalanx U2 L.5). Genetic studies also suggest that the sampled individuals possess haplotypes similar to offshore feeding aggregates (Royle 2017-01, see attached report). Genetic studies, at present, are limited, and their relevance to populations existing over 100 years ago is unknown. The life history of Green turtles is characterized by an Oceanic-Neritic Development Pattern (Bolten 2003) in which frenzied terrestrial hatchlings enter neritic zones (inshore marine water less than 200 m in depth from surface to floor) and after a short transitional period pass into oceanic epipelagic zones (water column at greater than 200 m in depth). Here they grow as juveniles feeding on neustonic (open water) planktonic material including crustaceans, comb jellies, and jellyfish. After pelagic juveniles attain carapace lengths of 20 to 45 cm, they return up to 10 years later to neritic (coastal where sunlight reaches the ocean floor) environments where they shift their feeding strategy to predominant herbivory (Arthur et al. 2008; Bolten 2003). Recent genetic analyses identify the CmP97.1 haplotype as orphans closely related to foraging (i.e., non breeding) haplotypes of the West Pacific and evidence of trans-Pacific associations (Chaves et al. 2017).

El Progreso was actively pursuing turtles, especially for oil. The marine specimens identified in the Carpintero midden may have also been brought to the interior highlands for consumption. It is interesting that no Galápagos tortoises were identified in the assemblage, although reports from around 1860 suggest that island tortoise populations had already been severely diminished on San Cristóbal, and were already exterminated on Floreana. Nevertheless, the studied sample is but a tiny portion of the industrial-scale midden, and tortoises may have been disposed of elsewhere, or even shipped live. Similar speculations can be raised by the absence of various other exploited animals, especially sea lions, which would have been procured on the beach, and subsequently processed locally, with preserved bone specimens deposited in unsampled contexts on the coast.

A small sample (NISP=18) of Iguanid specimens were recovered from various levels of the Carpintero midden, representing as little as two or three individuals. Almost three quarters of this sample (72%) are vertebral specimens (spines and centrae) with a few limb and girdle elements represented. The only native iguanid on San Cristóbal is the Marine Iguana (*Amblyrhinchus cristatus*), also specifically referred to as the San Cristóbal Marine Iguana (*A. C. mertensi*), which inhabits the rocky coastlines, intertidal areas, and marine waters up to 20 m in depth where it feeds on macrophytic algae.

Numerous valves from two species of large chitons were recovered in the Carpintero midden. They represent the large Giant Galápagos Chiton (*Chiton goodalli* NISP=535) which attains maximum lengths of 11-12.5 cm and the smaller and readily identifiable Sculptured Chiton (*C. sulcatus* NISP=53) which attains maximum lengths up to 9.5 cm. Both species are not only large but relatively abundant, particularly the Giant Chiton which congregates in groups of up to a dozen individuals in the narrow cracks between lava in the intertidal zone. All other native chitons are considerably smaller and less abundant (Smith and Ferreira 1977). Chiton shells are fairly ubiquitous today in scattered surficial contexts around the town site as villagers regularly access either coastline to harvest prized canchalagua, which is usually consumed in ceviche. The larger chitons are collected today under the light of the full moon by prizing them from intertidal rocks at night when they emerge to feed on microalgae. Although the Sculptured Chiton grows faster, the Giant Chiton is preferred for its size and volume of edible meat (Herrera et al. 2012; Murillo Posada 2010).

A variety of gastropods, bivalves, and sea urchins were recovered in smaller amounts from the midden. All tend to be common, shallow water, and principally intertidal species, native to the Galápagos Islands (Table 8). The exploitation of intertidal habitats, especially for

Taxon	**Habitat**		
Echinoidea			
Eucidaris	interidal to 150m		
Polyplacophora			
Chiton goodalli	intertidal along wave-washed coastlines		
Chiton sulcatus	mid littoral, rocky shores		
Gastropoda			
Fissurella	low littoral, surface-exposed rocks, infra littoral, mangroves, common beach litter		
Lottiidae	intertidal on rocks often exposed to surf		
Cerithium gallapaginis	intertidal, subtidal, infra littoral, sand flats		
Hipponix grayanus	intertidal, shallow water to 20m		
Cypraea albuginosa	intertidal and subtidal under rocks, to 80m		
Plicopurpura	mid to high littoral on exposed rocks		
Cantharus sanguinolentus	low intertidal in wave-washed areas,, shallow subtidal, on rocks		
Cancellaria gemmulata	offshore from shallow water to dredging depths		
Conus nux	lower littoral, subtidal to 10m, on rocks with algal growth		
Bulla	offshore, beyond tidal limit		
Bivalvia			
Arcidae	intertidal, anchored to rocks or crevices		
Pinctada	subtidal, shallow water		
Ostreidae	lower intertidal to dredging depths, often attached to rocks		
Pectinidae	subtidal		
Papyridea aspersa	subtidal		
Lucinidae	intertidal, subtidal, on sand		
Ctena	intertidal, subtidal, on sand, down to 25m		
Tornatellides cf. *chathamensis*	Caracól de Arbol/Tree Snail	1	0.00
Subulina cf. *octona*	Caracól/Miniature Awlsnail	1	0.00

Table 8. Marine Invertebrates recovered in excavation units from El Progreso and their habitats. Data from Hickman and Finet (1999) and Maluf (1991). Littoral (zone between high and low tide), Midlittoral (1m above low tide), Subtidal (below subtidal from shallow infralittoral to dredging depths).

chiton and other edible marine invertebrates like oysters, scallops, clams, lobster and crabs, as well as iguanids, is clearly supported by the deposition of various marine intertidal shells in highland midden context. Most of the El Progreso invertebrate specimens, like chitons, cling to rocks that are exposed at low tide. Other, non-tidal species like Bubble snails and Coral may be accidental bycatches. The marine gastropod Purpura is a source for Tyrian purple dye, released from its mucous glands (Hickman and Finet 1999:82). One small piece of coral, which is common in shallow water habitats around Galápagos, was identified from the Carpintero midden deposits. Two species of terrestrial gastropods were also identified in the deposits, and were undoubtedly accidentally intrusive. The common awlsnail (*Subulina ochotona*) is a common herbivore found in the mainland in acidic soils under pasturage with abundant organic materials (Correoso 2008:78). The tree snail (*Tornatellides chathamensis*) is a terrestrial gastropod of the Pacific islands, and endemic to southern Isabela and San Cristóbal where it prefers highland fern fronds (Dall and Ochsner 1928:179; Cooke and Kondo 1960:296).

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