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Chances for Arctic Survival: Greely's Expedition Revisited

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ABSTRACT. A.W. Greely's historic starvation camp of 1883–84 was revisited from April to June 1998. Our study revealed that the "sea fleas" reported to be the salvation of the expedition survivors were lysianassoid crustaceans *Onisimus edwardsi*. Expedition diaries reveal that the seven survivors of the 25-member expedition accumulated a huge energy deficit from October 1883 to June 1884. We estimate that their food supply (ship's rations, sparse game, and over 500 kg of carrion-feeding crustaceans collected in spring 1884) added up to about 4.8 million kcal. The minimal energy requirement of the group (5725 man/days and 1200 kcal/person/day) was 6.8 million kcal. The additional 2.0 million kcal might have been obtained from the bodies of victims. Without cannibalism, it seems unlikely that anyone, having attained an individual energy deficit of over 86 000 kcal before the rescue in June 1884, could have survived.

Key words: Arctic history, Ellesmere Island, amphipods

RÉSUMÉ. D'avril à juin 1998, on est retournés sur le site du campement de A. W. Greely qui, en 1883-1884, connut une famine historique. Notre étude révèle que les «puces de mer» auxquelles les survivants de l'expédition auraient dû leur salut étaient en fait des crustacés lysianassoïdes *Onisimus edwardsi*. Les journaux de l'expédition révèlent que, d'octobre 1883 à juin 1884, les 7 survivants de l'expédition, qui comprenait au départ 25 individus, accumulèrent un énorme déficit énergétique. On estime que leurs vivres (rations de marin, quelque gibier et plus de 500 kg de crustacés nécrophages ramassés au printemps de 1884) représentaient un maximum d'environ 4,8 millions de kcal. Les besoins énergétiques minimaux du groupe (5725 jours-personnes et 1200 kcal/personne/jour) étaient de 6,8 millions de kcal. Les 2,0 millions de kcal manquant auraient pu provenir des corps des victimes. Il semble en effet improbable que quelqu'un souffrant d'un déficit énergétique individuel supérieur à 86 000 kcal avant le sauvetage de juin 1884 ait pu survivre sans pratiquer le cannibalisme.

Mots clés: histoire de l'Arctique, île d'Ellesmere, amphipodes

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INTRODUCTION

The ill-fated U.S. expedition of the First International Geophysical Year 1882–83 to Lady Franklin Bay at Ellesmere Island, known as the "Greely Expedition" after its leader Adolphus Washington Greely, has been covered in great detail in popular and historical polar literature. Since the return of its survivors in 1884, an anonymous pamphlet (Anonymous, 1884), official diaries (Greely, 1886), and reports (Schley, 1887) have been published. Major semidocumentary narratives followed (Brainard, 1929, 1940; Todd, 1961; Guttridge, 2000), as well as a number of short papers (Bruno and Rockwell, 1984; Barnett, 1988; Myerson, 1996). The Greely expedition is mentioned in almost all books on polar history. The reason for this massive interest in the expedition is its tragic end: the loss of 19 men, evident blunders in the rescue operations, and political turmoil surrounding the expedition. The dramatic and heroic events, as retold by several colourful characters from the expedition, were all at the centre of public interest. However, the phenomenon of the survival of seven men has not been properly analyzed. Official reports (Greely, 1886; Schley, 1887) and later documentaries (Brainard, 1929, 1940) reveal that the seven men survived on scanty game and marine crustaceans collected at the campsite. Accusations of cannibalism, openly made immediately after the expedition's return (Anonymous, 1884), were denied by Greely himself, as well as by David L. Brainard, his next in command. Winfield Scott Schley (1887), who examined the mutilated bodies of the dead expedition members, wrote that the flesh had been removed, apparently to serve as bait for shrimps. Indeed the so-called "shrimps" were reported as a major food item for those who survived.

Having the opportunity to visit the Greely starvation camp in 1998, during the International Arctic Polynya Expedition, we surveyed the marine fauna that is supposed to have sustained the survivors of Greely's expedition. We present an explanation of the phenomenon of their survival based on field observations and literature studies, and we answer two questions: What was behind the death and survival of Greely's men in 1884? Would current scientific knowledge have provided a better chance for the survival of more men?

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MATERIALS AND METHODS

Field work was conducted from April to May 1998, in Rosse Bay, several kilometres south of Greely's starvation camp on Pim Island (Fig. 1). Baited traps were used to collect carrion-feeding organisms at depths of 2–100 m. Details on the sampling techniques and results have been published (Legeżyńska et al., 2000). Seaweeds were collected from ice cracks with a light dredge. Energetic values of organisms collected were determined, using bomb calorimetry, by Dr. Monika Normant at the University of Gdansk. All original weight data presented in the literature have been converted: 1 pound = 0.453 kg, 1 ounce = 1/16 pound = 28 g. The energetic values of different food items were taken from the *Dictionary of Calories* (1994).

RESULTS AND DISCUSSION

Setting the Scene

The 25 expedition members had twice wintered successfully at Fort Conger during 1881–82 and 1882–83. However, 18 men died after the retreat south to Cape Sabine, Pim Island, early during the third winter. Of those 18, two died of sickness (William Cross, January 1884 and Joseph Ellison, August 1884), one drowned (Jens Edward, April 1884), one was executed for stealing food (Charles Henry, June 1884), and one committed suicide (Octave Pavy, June 1884). The remaining 13 men apparently died of starvation. Greely had observed symptoms of scurvy, but not in all crew members and not in an acute form (Greely, 1886). Rescuers reached the seven survivors on 22 June 1884.

Food Supply – Basic Food

Landing on Pim Island in October 1883, the party of 25 men was supplied with 25 days' rations, and they found another 240 man/days of rations that had been left at Cape Sabine. Thus, in the beginning of the winter, Greely had about 35–40 full daily rations for the whole group. That was divided from 1 November into daily rations of 16 ounces per person, each worth some 900–1000 kcal (Table 1). That amount was distributed until 1 April in the following year, when daily rations were cut down to 4 ounces per person. The very last food from these rations was distributed among the survivors on 17 May 1884 (Brainard, 1929).

TABLE 1. Daily food ration established 1 November 1883, according to Brainard (1929).

Daily allowance	oz	g	kcal/100g	kcal
Meat	4	112	120	134
Beef extract	0.26	7.28	200	15
Dry potatoes	0.4	11.2	363	41
Soup	0.6	16.8	30	5
Tomatoes	0.3	8.4	20	2
Peas	0.2	5.6	70	4
Corn	0.2	5.6	66	4
Carrots	0.1	2.8	20	1
Bread	6	168	250	420
Dog biscuit	0.8	22.4	250	56
Butter	0.5	14	740	104
Lard	0.26	7.28	890	65
Rice	0.1	2.8	350	10
Raisins	0.16	4.48	290	13
Tea	0.3	8.4	1	0
Extract coffee	0.44	12.32	100	12
Extract chocolate	0.3	8.4	100	8
Pickled onion	0.4	11.2	25	3
Milk	0.2	5.6	479	27
Total	**15.52**	**434.56**		**924**

Game

Despite the fact that Pim Island is on the western edge of the North Water Polynya, an area regarded as an "oasis of life in the Arctic" (Fortier et al., 2000:5), the immediate surroundings are very much deserted and offer little opportunity for hunting. Observations of wildlife provided by Greely (1888), Bruno and Rockwell (1984), and our party in spring 1998 are strikingly similar (Table 2). Single marine mammals and occasional seabirds (but no bird colonies) have been reported in the area. Through occasional hunting trips, Greely's men collected not more than 400 kg of game (Table 3). Birds described as dovekies (*Alle alle*) by Greely must have been black guillemots (*Cepphus grylle*), since the reported amount of meat from an individual exceeded 1 pound (0.4 kg). The dovekie's total body mass never exceeds 0.17 kg, while black guillemots may reach over 0.5 kg (Muus et al., 1980).

Sea Food

The rocky coast of Pim Island and the extensive neighbouring Leffert Glacier provide a mixture of habitats, from rocky intertidal and hard-bottom shallow sublittoral areas to glacial muds. The hard bottom offers a habitat for kelp, of which *Laminaria saccharina* and *L. solidungula* (at depths of more than 20 m) were dredged in large amounts from the fast ice edge in 1998. Kelp density and biomass varied from place to place, and biomass was as high as 10 kg per m^2. Greely's men would occasionally dredge up some sea algae, from 2 to 20 kg at a time, adding it to the pot with other food items. Algae-associated animals are mainly the spiny isopod *Arcturus baffini*, small shrimps *Lebbeus polaris*, and small amphipod crustaceans (*Acanthostepheia, Ischyrocerus, Paroediceros*) and mysids (*Mysis oculata*). Crustaceans associated with macroalgae biomass ranged from 1 to 10 g wet weight per m^2. Both Greely's 1888 report and his scientific account (Greely, 1888) noted nearly all the species mentioned above. However, these animals were never used as food. Soft-bottom sublittoral in the area offers proper habitat for the number of carrion-feeding lysianassoid crustaceans. Since these species are active swimmers, their biomass is very difficult

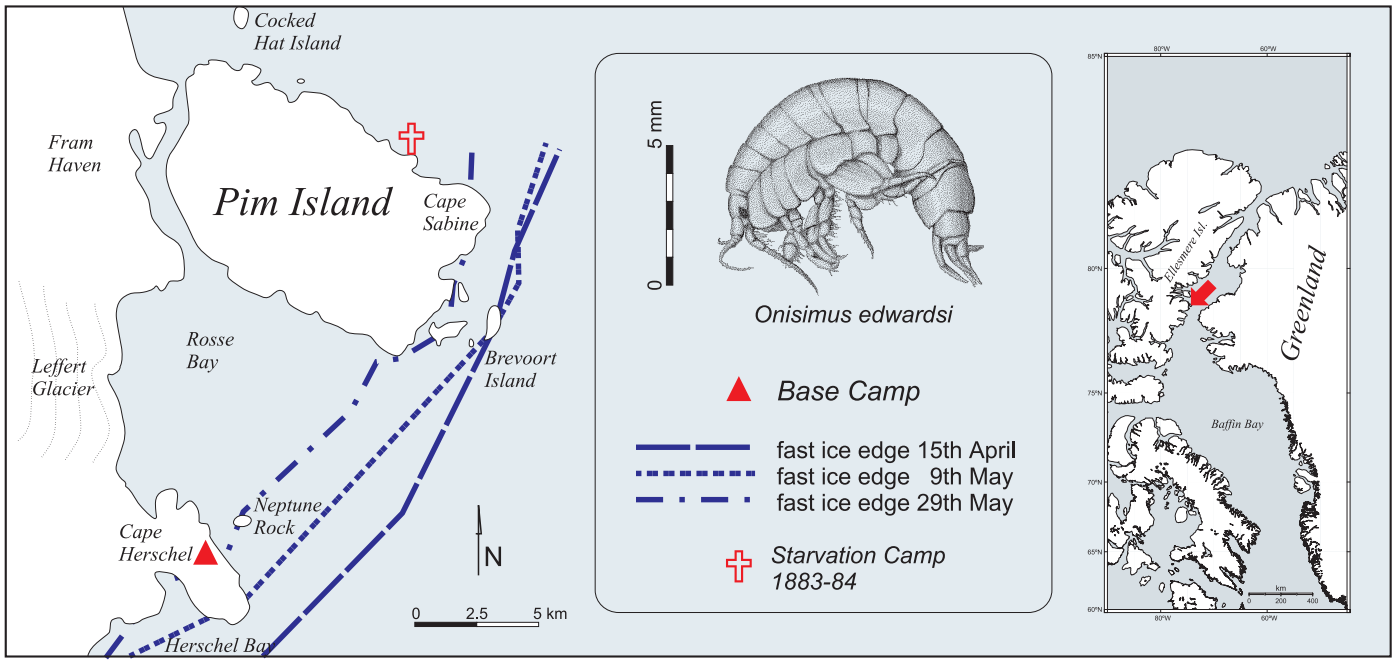

FIG. 1. The study area, showing locations of Greely's camp (cross) and the base camp for the 1998 marine biological survey (triangle) and the position of the fast ice edge facing the North Water Polynya in April-May 1998 (broken lines). The "sea flea" *Onisimus edwardsi*, a carrion-feeding amphipod crustacean, is pictured above the legend. The right-hand map locates the study area on Ellesmere Island.

to assess. The most common are 5–10 mm long *Onisimus edwardsi*, often observed in dense swarms at bait. These were the "shrimps" or "sea fleas" described by Greely and Brainard in their diaries. Working with baited nets from 20 March to mid-June 1884, Brainard and occasionally other crew members collected as many as 523 kg of those crustaceans (Table 3). Their catch supplied 43% of the energy (kcal) obtained by the crew between March and June and constituted 15% of the food supply for the entire winter.

Land Vegetation

Greely's crew collected unspecified amounts of green *Saxifraga* shoots, as well as the common black lichen *Umbilicaria* (rock tripe), and added these plants to the common boiling pot. However, some crew members refused to eat the lichens (Greely, 1888).

Other Food

In late April 1884, some men were reported to collect and eat large caterpillars from the camp area, but evidently this was not common (Greely, 1888; Brainard, 1929). The species must have been *Gynaephora groenlandica*, which attains almost 8 cm length and some 3 g weight. In May 1998, we found a number of those caterpillars among sun-heated stones in the area. Sealskin from the equipment, belts, boots, etc. was cut, boiled, and chewed, providing some remnant proteins, fat, and tannins. The nutritional value of skins and leather was proved during the Franklin expedition (Houston, 1984).

Water Supply

Water was apparently in good supply, but since it came mainly from melted snow, it was probably low in mineral salts. On the other hand, the kelp and black lichens mentioned above may have provided some of the needed microelements and vitamins.

The Energetics of Starvation

When provided with water and microelements, people are able to survive voluntary dietary exercises or religious fasting (Edholm and Bacharach, 1965) for prolonged periods, even up to 70 days (Kozłowski, 1986). Nevertheless, the deficit of energy accumulates, and since the organism is burning its own tissue, there is a critical point of no return. Fatal and irreversible loss of body mass, reported in different studies, ranges from 30 to 60%. An average man weighing 70 kg has some 20% fat, 9% proteins, and 60% water. The loss of water alone is fatal when it exceeds 20% of body mass. But the fatal weight loss of a starving man, who is losing fat and proteins as well as water, might be in the range of 40% of body mass (Kozłowski, 1986). The caloric value of a 70 kg man's body tissue approximates 170 000 kcal (Kozłowski, 1986).

Energy loss in a cold climate increases because the cold air inhaled has to be heated and humidified by the respiring organism (Webster, 1947). R.F. Scott's sledging party heading for the South Pole had meagre daily rations of 4200–4500 kcal per man (Feeney, 1997). Recent experiments with energy expenditure during sledging indicate that an average 5500 kcal deficit equals 1 kg of weight loss

TABLE 2. Wildlife observations made by different groups in the area of Pim Island.

Taxon	Greely, 1884 October–June	Bruno and Rockwell, 1984 August	Present authors, 1998 April–June
Arctic fox *Alopex lagopus*	6	x	2
Arctic hare *Lepus arcticus*	2	x	1
Bearded seal *Erignathus barbatus*	1	x	2
Black guillemot *Cepphus grylle*	?	x	440
Common eider *Somateria mollissima*	0	x	74
Dovekie *Alle alle*	?	0	0
Fulmar *Fulmarus glacialis*	0	x	1
Glaucous gull *Larus hyperboreus*	0	x	32
Greenland seal *Phoca groenlandica*	0	0	2
Kittiwake *Rissa tridactyla*	0	x	2
Narwhal *Monodon monoceros*	0	0	10
Polar bear *Ursus maritimus*	3	x	2
Ptarmigan *Lagopus mutus*	6	x	4
Raven *Corvus corax*	4	x	3
Ringed seal *Phoca hispida*	4	x	1
Walrus *Odobenus rosmarus*	0	0	2
White whale *Delphinapterus leucas*	1	x	0

TABLE 3. Food supply and individual energetic values obtained during the 1883–84 wintering.

Item	Fox	Guillemot	Seal	Ptarmigan	Raven	Bear	Kelp	Amphipods	Base food	Human flesh	Total kg
Average individual weight (kg).	2	0.4	27	0.5	1	147				15	
Energy kcal/100 g	100	120	200	120	120	110	30	100	22	120	
October	6		81	1					700		788
November	20		27						313		360
December	16								313		329
January	2								313		315
February	2								313		315
March	2	19		1				18	313		353
April		4.5	27	1		147	20	300	150	75	724.5
May		0.4			1		18	180	93	60	352.4
June		2						24	0	105	131
Total	48	25.9	135	3	1	147	38	522	2508	240	3667.9

in Arctic conditions (Table 4). Greely and his party, except for occasional hunting trips, were for the most part sedentary. Durnin (1981) shows that an average man of 65 kg weight, spending the day in the bed, burns between 1200 to 1700 kcal/day. In addition, basal metabolic rates decline to below normal levels in response to undernutrition (Edholm and Bacharach, 1965), so we may take the lowest possible figure of 1200 kcal/man/day as a bottom line.

Considering the monthly budget of supplies and the number of people alive (number of man-days for each month), the group started in October with a supply of 20 000 kcal and energy demand over 80 000 kcal, which resulted in a 30 000 kcal deficit in November. This deficit continued to accumulate through the following months (Fig. 2), reaching the critical value of over 70 000 kcal per person by the end of March. Once this critical value was surpassed in April, the first five victims died. In May and June, the energy deficit again increased; four people died in May and five in June. It is amazing (if not impossible) that the remaining seven people were able to survive with an energy deficit of over 110 000 kcal by 22 June (Fig. 2).

Considering the reports of cannibalism, we speculate that the 13 mutilated bodies exhumed by Schley's party, as well as three others that have never been found, were used as a last-resort food supply. Supposing that the maximal amount of meat from a skinny cadaver is 15 kg, the survivors (at best) got 240 kg of additional food from this source in May and June 1884. Considering the energetic value of tissue as 120 kcal/100 g, this fulfills the missing individual requirement needed to stay above the threshold of death at the deficit of 86 000 kcal (Fig. 2).

Cannibalism has scarcely been documented in Arctic expeditions (Rowley, 1950; Mary-Rousselière, 1969; Houston, 1984; Simpson-Housley, 1999). One of the most complete investigations was of the third Franklin expedition, whose whole party of 129 men finally perished (Berton, 2000). Recent forensic examination of the bones clearly showed characteristic knife cuts on long bones, confirming the Inuit reports on cannibalism of that time (Keenleyside, 1995). McDougall (1977) reports that after an airplane crash in 1971 in the Canadian Arctic with two survivors, one died after 16 days refusing to eat human flesh, while the other survived 32 days on the body of the third victim (Table 4). Reports of cannibalism from 19th century Arctic expeditions were usually not accepted officially, since the fallen adventurers (even if deceased) were

TABLE 4. Examples of human weight and energy loss in Arctic conditions.

Author	Days	Energy intake (kcal/day)	Energy expenditure (kcal/day)	Initial weight (kg)	Weight change (kg)	Total deficit (kcal)	kcal/kg	% weight	Daily weight loss (%)
McDougall 1977	14	10	2000	43.5	10.9	27860	2556	25.1	1.79
Feeney 1997	20	3050	3895	64.2	1.6	16900	10563	2.49	0.13
Feeney 1997	7	4420	5045	79.5	1.25	4375	3500	1.57	0.22
Feeney 1997	21	3155	3250	71.2	1.7	1995	1174	2.39	0.11
Feeney 1997	7	3320	4085	70.1	1.6	5355	3347	2.28	0.33
Feeney 1997	19	2560	3990	78.5	1.7	27170	15982	2.17	0.11
Feeney 1997	14	2365	2870	64	1.5	7070	4713	2.34	0.18
Moskal 1995[1]	70	4500	5100	90	15	42000	2800	17	0.24

[1] W. Moskal, pers. comm. 1995. W. Moskal, oceanographer and explorer, sledged with M. Kaminski to the North Pole in 1995, without airdrops or other external support. He is at present at the Institute of Oceanology Polish Academy of Sciences, in Sopot, Poland. E-mail: wojtek@iopan.gda.pl

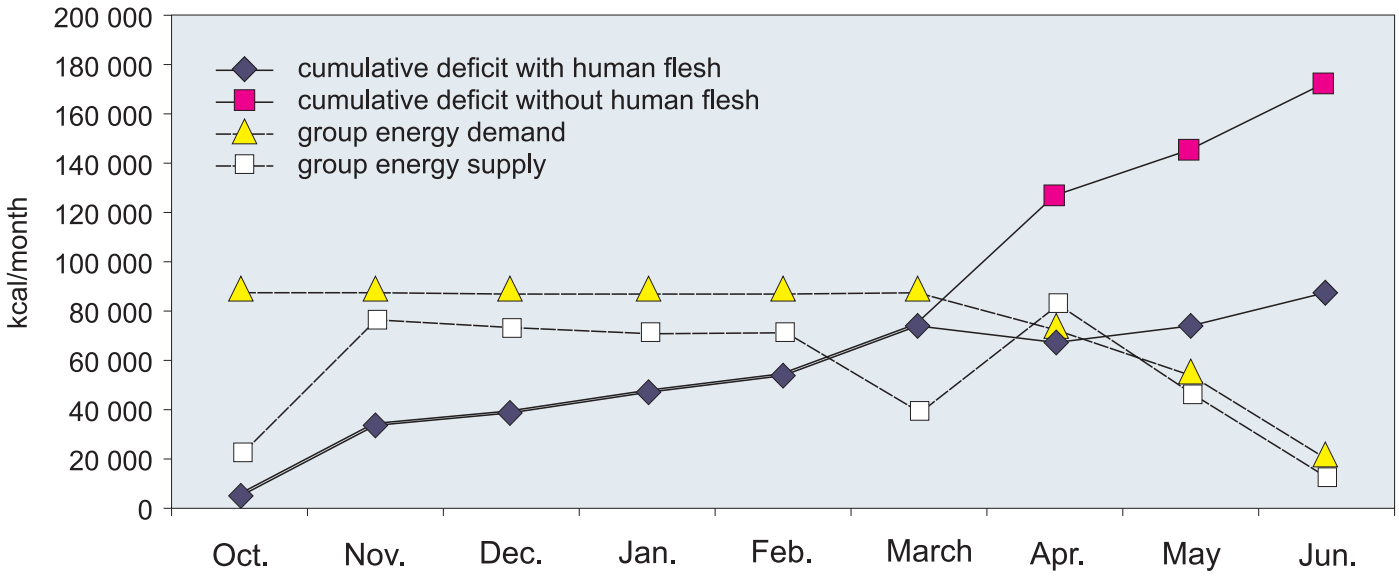

FIG. 2. Energy supply and demand and cumulative energy deficit during Greely's 1883–84 wintering at Cape Sabine.

needed as national heroes, which was the case with the Franklin party. The same happened after Greely's return (Feeny, 1997; Simpson-Housley, 1999). The Greely survivors denied the accusations of cannibalism and declared that they had survived on "sea fleas" and remnant provisions. Given the paucity of available game and the low energy value of seafood, the amount of carrion-feeding amphipods that the Greely survivors would have had to catch to survive would have been at least 1500 kg, amounting to 1 800 000 kcal.

Were There Other Possibilities?

Guidelines on survival given by Stefansson (1921) in his famous book *The Friendly Arctic* could be adopted only by small, moveable teams able to follow their prey. In fact, at the turn of the century there were other examples of small parties that struggled successfully for life over long periods in the High Arctic (Nansen, 1900; Albanov, 2000). Greely's large group, stranded in winter and without dogs, had no chance to adopt such a mode of survival. The party's Inuit hunters, from southwest Greenland, were not familiar with hunting in the High Arctic. Suitable game was not available in the area, and the seaweeds were inadequate food because of their low nutritional value. Three months of shrimping near the camp provided Greely's party with 523 kg of amphipods; the catches were apparently low during the last weeks. Considering that the density of carrion-feeding amphipods might be on the order of 1 g ww per m^2, that the reaction to bait takes place at best within 100 m of the bait, and that the place of harvesting was changed from time to time, we may conclude that the coastal zone of at least 5 km length was severely overexploited (500 000 m^2 = 500 kg of crustaceans). Changing the depth of sampling from shallows to at least 60 m might have been beneficial, since in deeper water much larger species prevail (like the 4 cm long *Anonyx nugax*; Legeżyńska et al., 2000), and they are equally easy to get into the traps. For some strange reason, nobody from the party was interested in a closer look at the "sea fleas." Other organisms of no vital importance had been preserved in alcohol, meticulously sketched, and

described for further analyses by specialists (Greely, 1888). Detailed descriptions of aurora borealis and sound velocity experiments filled a number of pages in their diaries and reports. Still, the biology of their supposed life-giving amphipods was disregarded.

Increase of catch effort, through the involvement of more party members in the "shrimping" over a wider catch area and larger depth span, might easily have improved their catch success. However, these improvements could have not saved their lives. Even double the amount of crustaceans would not have provided enough energy for all the survivors. For this reason, it seems certain to us that the prolonged survival of some men was due to their engaging in cannibalism, the fact so desperately disregarded in the official documents. We are not stating that all expedition members or any specific persons were involved in cannibalism. For example, the frostbitten Ellison, who was unable to move out of the tent, was certainly not able to get human flesh by himself, although he could have received it from one of his colleagues. Some of the more active crew members (e.g., cooks and shrimpers) may have more opportunities to get some additional food. Individual differences in the crew members' body constitution and health might be of importance, as well as their habits (smoking vs. nonsmoking, sedentary vs. active lifestyle). Our conclusion is that, as a whole, the group could not have lived that long and partly survived without an additional, undocumented food source, and the most obvious choice was cannibalism.

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