OCEANIC DRIFT OF GOURDS—EXPERIMENTAL OBSERVATIONS [1]

Thomas W. Whitaker and George F. Carter [2]

THE WHITE-FLOWERED GOURD, *Lagenaria siceraria* (Mol.) Stand. is generally considered to be a native of the Old World, possibly Africa. However, like the cultivated species of *Cucurbita*, there are no records of its having been found in the truly wild state. There is much solid archaeological evidence to indicate that it was present in the Americas in pre-Columbian times. Perhaps the earliest recorded occurrence of this species in the New World is that from Huaca Prieta, Peru (Whitaker and Bird, 1949). Bird (1948) estimates the age of this site at about 3000 B.C. If it be conceded that *Lagenaria* is an Old World species, the method and time of transportation to the New World are problems of first importance for plant geographers, ethnobotanists, archaeologists, and others.

At least one aspect of the problem is subject to experimental attack. If it can be shown that the gourds are capable of floating for prolonged periods of time in sea water, with the seeds remaining viable, there exists the possibility that fruits of *Lagenaria* may have been transported to the New World by oceanic currents. This possibility has been suggested by Towle (1952), and she cites certain pieces of evidence from the literature to support this idea.

Very little is known about the distribution of plants through the agency of oceanic currents, and there has been no thorough investigation of this important subject in recent years. Guppy's (1917) work, a classic in this field, still remains the only source of reliable information about the oceanic drift of plant materials. Although Guppy made some extensive observations on the drift of the calabash gourd (*Crescentia cujete*), *Lagenaria* is mentioned only incidentally and, except as noted below, his observations are for the most part not pertinent to our problem.

According to Guppy, gourds have been familiar to naturalists of Scandinavian countries since the eighteenth century as a constituent of the foreign plant drift cast up on their shores by the Gulf Stream. These gourds have been referred in most cases to *Lagenaria*. Guppy regards this as an error. He thinks it highly probable that some if not all of the gourds and calabashes recorded from Scandinavian beach drift were fruits of *Crescentia cujete*. Their association with typical tropical plants and seeds which are commonly carried by the Gulf Stream from the West Indies to Scandinavian shores make Guppy's suggestion seem logical. Moreover, *C. cujete* is widely scattered over the West Indies, and the fruits are characteristic of the beach drift of these islands. The writers are inclined to agree that these early records of gourds must have been the fruit of *C. cujete*, rather than *Lagenaria*.

Elsewhere, in his discussion of the drift of plant material, Guppy states that gourds and calabashes of cucurbitaceous plants are frequently brought down to the sea in tropical regions by natural agencies, and from here are likely to be dispersed by ocean currents. As an example he cites his observations of gourds of a species of *Cucurbita* floating in the estuaries of Fiji. One gourd floated for at least two months in sea water, and the seeds germinated within a few days after planting.

If *Lagenaria* was transported from the Old to the New World by ocean currents, the most obvious possibility would be via the South Equatorial Current from the coast of tropical Africa to the coast of Brazil. It is unfortunate that oceanographers know very little about the rate of flow of the South Equatorial Current. The few measurements that have been made indicate velocities of between 1 to 2 knots, but it is estimated that velocities as high as 3.5 knots occur (F. C. Fuglister—personal correspondence). A further complication exists along the Brazilian coast, in the South Atlantic, where the extension of the South Equatorial Current is separated from the coast by irregular countercurrents. Thus, for a gourd to reach the shore, the direct effect of the wind would very likely be an important factor, possibly even more important than ocean current velocities. If we take all these factors into consideration the best estimate suggests that a gourd would have to remain afloat a minimum of 145 days to be carried by oceanic drift from Africa to the Brazilian Coast (4000 miles at 1 knot).

EXPERIMENTAL.—In a preliminary test (Seitz and Carter, 1952) gourds were floated in the Chesapeake Bay at two locations. The results of these experiments, while marred by technical difficulties and too few available samples, were nevertheless highly suggestive. A record of up to 75 days afloat, with irregularly decreasing seed viability, was reported. It was clear that gourds could float in salt water for a considerable period of time, and still retain some viable seeds.

These preliminary data indicated that a more adequate experimental test would be of value. Accord-

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ingly two large enamel-coated bathtubs were set up in series on the pier of the Scripps Institution of Oceanography, La Jolla, California. A supply of water pumped from the sea flowed through the tubs almost continuously. Twelve gourds were placed in each tub. At four-week intervals, two gourds selected at random were taken from the tanks and seedling emergence tested, along with seed from a control gourd stored in a warm dry environment.

When sufficient seed was available, 100 seeds were used for the emergence test. Some gourds contained fewer than 100 seeds; in such cases the entire quantity of seed was used for the test. Usually only 24 seeds were used in testing seedling emergence of the control. The seeds were planted in 6-inch pots in good garden soil, and grown in the greenhouse.

Emergence was scored between 17–25 days after planting. Seeds from the floated gourds appeared to produce seedlings equally as rapidly as those from the controls. When compared with plants from the control gourd, the young seedlings of the floated gourds appeared to be perfectly normal. Most of the gourds, when opened to obtain the seeds, had become moist and damp within the cavity. However, with two exceptions there was no free water in the cavity. Even when free water was present, the seeds had not commenced to germinate.

For the most part, the gourds floated in an upright position. After floating for two weeks or more they assume a stable position, from which it is impossible to dislodge them. They react like a weighted-base doll, returning to the position with the heavy end downward when attempts are made to displace them.

Marine growth commenced almost immediately after the gourds were placed in the tanks. After two weeks the immersed portion of the gourds was covered with a rich growth of algae and bacteria. Within a month, barnacles, mussels and other small animals became imbedded in the matrix of the algae and bacteria.

The average surface temperatures of the water for the months during which the test was run were as follows:

July,	1953	20.57°C	November,	1953	15.90°C
August,	"	20.69°C	December,	"	14.25°C
September,	"	17.63°C	January,	1954	14.10°C
October,	"	17.61°C	February,	"	14.32°C

TABLE 1. *Emergence of seedlings from gourds floated for various lengths of time in sea water (24 numbered gourds placed in tanks 7/7/53).*

Gourd No.	Days afloat	Date Planted	Date Scored	No. seeds planted	No. seedlings emerged	% emergence
5	28	8/4/53	8/25/53	100	80	80
11A	28	8/4/53	8/25/53	100	98	98
Control		8/4/53	8/25/53	24	24	100
2A	56	9/2/53	9/25/53	100	88	88
7A	56	9/2/53	9/25/53	100	81	81
Control		9/2/53	9/25/53	24	22	91.67
3A	84	9/29/53	10/16/53	100	87	87
7	84	9/29/53	10/16/53	100	90	90
Control		9/29/53	10/16/53	24	20	83
4[a]	112	10/27/53	11/24/53	100	0	0
1	112	10/27/53	11/24/53	78	77	98
Control		10/27/53	11/24/53	24	17	71
5A	140	11/24/53	12/18/53	100	95	95
3	140	11/24/53	12/18/53	100	65	65
Control		11/24/53	12/18/53	24	21	89
8A	168	12/22/53	1/7/54	100	92	92
9A	168	12/22/53	1/7/54	100	59	59
Control		12/22/53	1/7/54	24	24	100
9	196	1/19/54	2/8/54	100	43	43
6A	196	1/19/54	2/8/54	100	77	77
Control		1/19/54	2/8/54	24	24	100
6[b]	224	2/16/54	3/3/54	100	93	93
11	224	2/16/54	3/3/54	100	67	67
Control		2/16/54	3/3/54	24	24	100

[a] This gourd was very heavy, and the cavity was overhalf filled with water.
[b] This gourd partially submerged when seed sample taken.

It seems fair to assume that the temperatures of the water in the tubs were not greatly different from the temperatures recorded above, since the intake to the pump is adjacent to the location where the temperature readings are taken, and the water from the tubs comes directly from the pipeline, a few feet from the pump.

The data from the gourd floating experiment are summarized in table 1. It is evident from this table that, with one exception, the seedlings from gourds afloat up to 224 days emerged on the whole as well as did seedlings from the control gourds kept in dry storage. There is no evidence of regression of rate of seedling emergence with time afloat. This conclusion is supported by a conventional statistical analysis of the data. It is to be expected that seed samples from different gourd fruits would vary considerably in seedling emergence. Environmental factors such as individual plant vigor, position of fruit on the vine, maturity of fruit at harvest, etc., undoubtedly have some effect upon emergence. These sources of variation probably account for the relatively wide difference in seedling emergence between some fruits. Not a single seed from gourd No. 4 produced seedlings although over 200 seeds were tested. This result suggests that the seed was non-viable before the floating experiment commenced.

Emergence of seeds immersed in sea water.—With the thought that some additional information might be obtained by immersing seeds in sea water and testing seedling emergence at different intervals of time, a quantity of seeds were introduced into the water, where they sank to the bottom immediately. Table 2 is the record of these experiments. It is evident that there was no lowering of emergence of seedlings when the seed was immersed in marine water up to a period of 98 days. In fact there is a trend that suggests a stimulating effect from immersion. However, the data are not critical with respect to this point.

DISCUSSION.—The data reported in this paper indicate that under the conditions of the experiment gourds will float up to a period of seven months or more in marine waters, with good survival of viable seed. This does not necessarily mean that they would float in the open ocean for this length of time or that they were transported from Africa to South America by oceanic drift. We can never have a positive answer to this question until gourds are released along the African coast and actually picked up on the shores of Brazil. There is the further difficulty that after reaching the beach, the gourds would either have to be picked up by man and planted, or they would have to be broken open by natural agencies, exposing the seeds for transport inland by animals or other agencies, since *Lagenaria* appears not to be a strand plant.

The evidence accumulated from these experiments strongly suggests that gourds of *Lagenaria siceraria* have the potentiality of reaching the shores of South America from tropical Africa by means of oceanic drift, with seed viability practically unimpaired.

The seed immersion tests indicate that seeds of *L. siceraria* can be immersed for prolonged periods of time without appreciably hampering viability. This suggests that sea water per se is not harmful to the seeds, and leads to the conclusion that, if the gourds are capable of floating, free sea water within the seed cavity is not likely to affect seed viability adversely.

One other piece of evidence deserves mention. Several gourds were floated in small tanks with the wood-boring mollusk *Teredo*. These gourds sank after a period of 60 days. Many of the organisms had perforated the shell with innumerable small holes. This indicates that the shells of *Lagenaria* are not impervious to boring organisms. However, we are told that boring and drilling organisms are characteristic of littoral areas, rather than the open ocean. For this reason, hazards to floating from this class of organisms would probably be at a minimum, at least in the open sea.

There were some significant variations in experimental results between those obtained at Chesapeake

TABLE 2. *Emergence of seedlings from Lagenaria seeds immersed in sea water for various periods of time.*

Treatment	No. seed planted	No. seedlings emerged	Date planted	Date scored	% emergence
Sea Water					
16 days	24	24	9/2/53	9/25/53	100
Control	24	22	9/2/53	9/25/53	92
Sea Water					
40 days	19	19	9/21/53	10/16/53	100
Control	24	20	9/21/53	10/16/53	83
Sea Water					
56 days	23	23	10/14/53	11/16/53	100
Control	23	17	10/14/53	11/16/53	74
Sea Water					
98 days	16	15	11/26/53	12/18/53	94
Control	24	21	11/26/53	12/18/53	95

Bay and those reported from La Jolla. In the Chesapeake Bay experiments, some seeds sprouted in the gourds, mold-producing fungi were active within some gourds, there was decay and putrefication of the interior contents, and there appeared to be a general decline in seedling emergence with time.

It seems probable that these differences may be accounted for by a combination of factors, chiefly salinity and the organic content of the water. In the brackish waters of parts of the Chesapeake Bay, the salinity is relatively low, and the organic content high in comparison with sea water. This combination tends to promote lush growth of microorganisms and fungi. However, the two experiments do suggest that gourds are capable of long oceanic drift with seed viability little impaired, provided woodboring organisms do not attack the gourd during its period of littoral drift.

SUMMARY

Under conditions simulating oceanic drift, gourds of *Lagenaria siceraria* were found to be capable of floating for periods up to 224 days with no significant decrease in viability of the seed. From what is known of the velocities of oceanic currents, this length of time would be sufficient for gourds to drift from tropical Africa to the coast of Brazil by the South Atlantic Current. Up to 95 days immersion in sea water did not impair viability of the seeds as compared with dry controls. This would indicate that the critical factor in the distribution of this species by oceanic drift is the ability of the gourd to float.

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A POSSIBLE SOURCE FOR AMERICAN PRE-COLUMBIAN GOURDS [1]

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THE PROBLEM of long-distance plant dispersal is one surrounded by a considerable amount of speculation. Therefore, the study by Whitaker and Carter (1954) on the viability of the seed of the gourd (*Lagenaria siceraria*), after being floated in sea water for a considerable time, is of great importance.

Those of us interested in plant distributions (Camp, 1947) welcome precise data on such matters. We have never discounted the fact that winds and ocean currents have been effective agents in plant dispersal, often over long distances. However, results of experiments such as that conducted by Whitaker and Carter should not lull us into thinking that all perplexing problems related to trans-oceanic disjunct distributions are to be resolved in the manner they suggest.

Ridley (1930) has given us an excellent list of plants potentially transported by winds and ocean currents. However, as noted elsewhere (Camp, 1952), in carefully examining Ridley's voluminous compilation one searches in vain for certain forms, especially among the more primitive members of critical groups. Ridley was completely aware of this situation, and often commented on the wide dispersal of certain plants with no apparent means of accomplishment. *Lagenaria siceraria* does not belong to this perplexing group of organisms.

In their report, Whitaker and Carter remark: "If *Lagenaria* was transported from the Old to the New World by ocean currents, the most obvious possibility would be via the South Equatorial Current from the coast of tropical Africa to the coast of Brazil." The general concept of a dispersal from Africa to South America is the only one considered by these authors in their paper.

Whitaker and Carter are correct in pointing out that this gourd is not a littoral plant. Therefore, even if it drifted from Africa to Brazil, it would—as they clearly indicate—have to be transported inland. According to these same authors, the earliest known record for this gourd in America is from the ancient Huaca Prieta site in Peru. The problem, therefore, would be its transport across the width of South America and over the Andes. This is not impossible, but another item might be considered.

The exact place of origin for this gourd is unknown. Macmillan (1946) implies that it is native in southeastern Asia, although sometimes thought to be African; his guess probably is as good as any at the present time. Of the plant as grown in Ceylon he says (under its formerly accepted synonym, *L.*

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