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NOTE CONCERNING *PHYSALIA* BEHAVIOR AT SEA[1]

ABSTRACT

Observations of *Physalia* from an open boat at sea show that pneumatophore dipping frequency increases with wind speed, and experiments suggest that muscular contractions due to osmotic pressure differences may cause the dipping.

The float-dipping behavior of the sailing siphonophore *Physalia physalis* (L.) has been observed by mariners for many years. Muscular contractions and contortions of the float associated with the dipping and righting behavior were recently described by Mackie (1960) and photographically illustrated by Totton (1960). However, some of the observations concerning this performance are confusing. Totton suggested that the "rolling" (dipping) frequency decreases with increasing wind, but observations by Hardy (1956) and Savilov (1961) suggest an opposite effect due to the drying action of winds. At the risk of adding to the confusion, I here report more observations.

During March 1961, I spent several hours in an open boat continuously observing individual *Physalia* on the Atlantic Ocean, about 16 km east of Palm Beach, Florida. A small lifeboat was launched for the purpose from the RV *Eugenie VIII*, of the Woods Hole Oceanographic Institution. Counts were made of the dipping frequency of the floats, while the boat was kept a few meters downwind from the animals to avoid disturbing the air flow over them. Motion pictures of the *Physalia* activities were taken. The dipping performance required only a few seconds—the float quickly returning to the erect upright position. Upon becoming upright again, the crest of the float was often collapsed after dipping, but it was reinflated rapidly. Mackie (1960) said that crest collapse and erection is due to changing tension in float musculature.

Wind speed, temperature, and relative humidity were also measured during the *Physalia* observations, using a cup anemometer and sling psychrometer at about 1.5 m over the sea surface. The results of these measurements indicate an increase in dipping rate with wind speed (Fig. 1). The data are of course highly limited in number. But in my opinion the increase with wind speed was not unique to these three animals but was characteristic of the

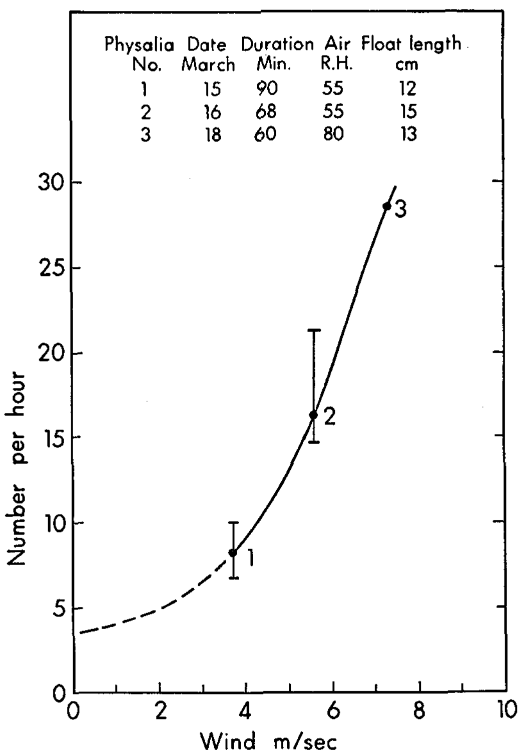

FIG. 1. Observations of *Physalia* dipping rate as a function of wind speed, Strait of Florida, 26° 45′ N, 79° 50′ W, 1961. The uncertainty bars show range of difference in rate over the periods of observation, based on time interval between individual dips. For animal 3, only the number of dips during the entire observation period was determined. The value at zero wind is assumed.

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behavior of the many *Physalia* scattered broadly over the sea at these times. Later work may show whether the dipping frequency also varies with float size and air relative humidity. A rate inversely related to relative humidity and directly related to size is anticipated, if drying is the controlling factor. During high winds, breaking waves and flying spray may prevent drying by frequently wetting the float with seawater.

After the dipping observations on one of the days, I sprayed the float of the *Physalia* briefly with seawater from a syringe, at 2-min intervals over a period of 24 min, wetting both windward and leeward sides of the float. During this time all dipping stopped.

Savilov (1961) suggested that intensified evaporation from the pneumatophore in dry atmospheres causes more frequent "inversions" (dipping) and that drying may be a factor limiting their geographical distribution. The results shown in Fig. 1 support Savilov's suggestion concerning dipping frequency, since evaporation is a function of wind speed.

Physalia float surfaces coated with a film of seawater will not become dry, however, at the usual humidities over the sea. Evaporation removes water vapor—the rate of removal being markedly affected by wind speed—leaving a brine having an equilibrium concentration which is a function of the relative humidity. For instance the equilibrium salinity of a sea-salt solution in air at a relative humidity of 95% is about 100‰ (Arons and Kientzler 1954), or about 3× the salinity of the Atlantic surface waters.

After the seawater spray test reported above, I made a second spray experiment using seawater concentrated by evaporation to a salinity of ~100‰. This more saline spray, directed towards the upwind side of the float, produced marked muscular contraction of the windward side of the float and immediate dipping on each of the many times it was used. Again erection of the float followed shortly after each dipping.

These preliminary observations and experiments suggest that a higher salinity and osmotic pressure naturally occur on the exposed windward side of the float, due to a higher evaporation rate there than on the sheltered leeward side. The osmotic pressure difference may stimulate stronger muscular contractions on the windward side sufficient to alter the stability of the float and to produce the dipping. Upon contact with seawater the brine is rapidly washed away, musculature relaxes, and float erection recurs, as demonstrated in the brine spray experiment. I propose therefore that osmotic pressure differences are one of the main factors controlling the dipping of *Physalia* under natural conditions.

These observations and others (Woodcock 1956) are only a beginning in the study of the behavior of the *Physalia* within the highly variable boundary layers of the sea and the atmosphere.

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ALFRED H. WOODCOCK

Department of Oceanography,
Hawaii Institute of Geophysics,
University of Hawaii,
Honolulu 96822.

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