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EFFECT OF HOUSING SHAPE ON THE CATCH OF RECORDING GAGES

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ABSTRACT

The reduction in catch due to the shape of the housing of the U.S. Weather Bureau standard recording gage was explored using data from Weather Bureau stations with both recording and nonrecording gages, a gaging site which included both a standard nonrecording gage and a Stevens recording gage, and gages on the East Central Raingage Network. It was found that, on the average, the standard 8.0-in. diameter orifice recording gage caught 2.5 to 6 percent less rain than the nonrecording gage and 2.5 percent less rain than the recording gage fitted with a 12-in. diameter orifice. The Stevens recording gage caught 5.5 percent less rain than the nonrecording gage. It is concluded that proximity of a sloping portion of the gage housing on the 8-in. diameter orifice recording gages is responsible for the catch reduction.

1. INTRODUCTION

Eichmeier (1965) has discussed the difference in catch between an early model of the weighing-bucket precipitation gage and the present U.S. Weather Bureau standard model. After a 3.5-mo comparison period near Coshocton in east-central Ohio, he concluded that the reduced catch of 10–15 percent in the older model was caused by the proximity of a sloping shoulder of the gage housing to the sampling orifice. This gage (fig. 1A) has a short stack extension of only 3 in. Wind deflected upwards by the shoulder tends to sweep raindrops away from the orifice. The present model of the standard (fig. 1D) has a longer stack extension that places the orifice 5.75 in. above the sloping shoulder. Although the stack extension is longer on the present gage, the basic design shape of the sloping shoulder below the orifice remains to influence the flow of the air over and about the gage.

It has also been pointed out by Riesbol (1940) that the early Fergusson recording gage consistently caught less precipitation than a nearby nonrecording gage, "due to the sloping shoulders on the recording gage which cause updrafts."

2. COMPARISON OF STANDARD RECORDING AND NONRECORDING GAGES

Data from two U.S. Weather Bureau and Environmental Science Services Administration Cooperative Substations in Illinois (1958–1967), each with a weighing-bucket recording gage (fig. 1D, Universal Recording Rain and Snow Gage, U.S.W.B. Spec. 450.2201) and a nonrecording gage (fig. 1B) have been examined. Both types of gages have 8-in. diameter orifices and no wind shields.

The substation at Farmer City has been in continuous operation with the same observer since 1962. The gages are in a sheltered farmyard. Data were available for July 1, 1962, through June 30, 1967. The substation at Danville has been in operation since 1958; and, except for a few breaks in the records due to changes in location and observers in 1959, data are available for Jan. 1, 1958, through June 30, 1967. The gage location since 1959 has been in an open area in a sheltered river valley. The

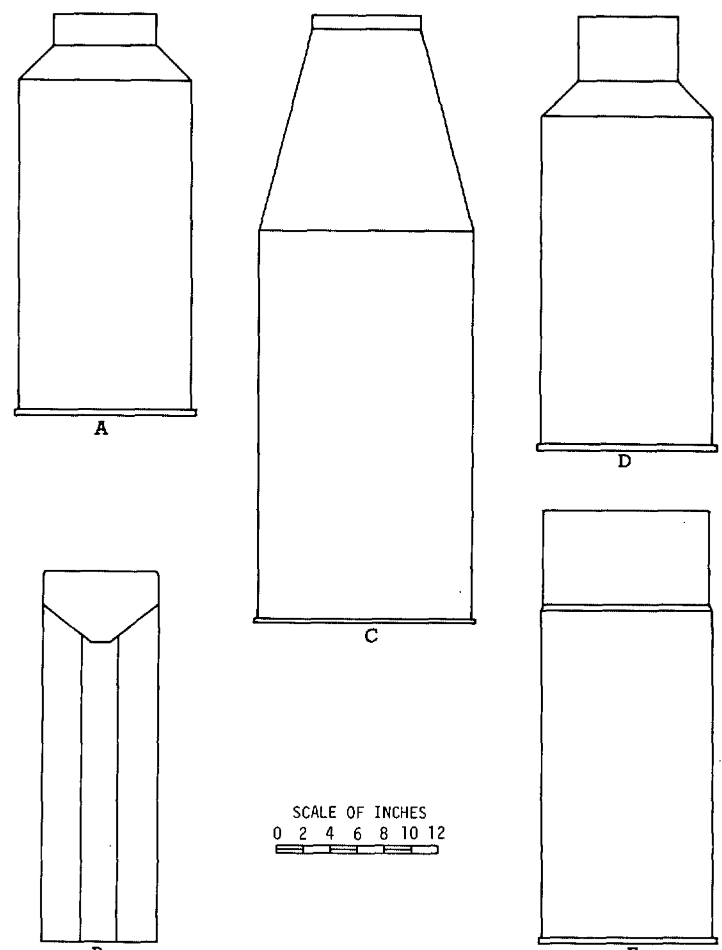

FIGURE 1.—Housings for standard recording raingages. (A) Universal Survey Gage, 1938; (B) U.S. Weather Bureau standard nonrecording gage; (C) Leupold and Stevens Q-12 Precipitation Recorder; (D) Universal Recording Rain and Snow Gage; and (E) Universal Recording Rain and Snow Gage with 12.648-in. diameter orifice.

two gages at both stations are 42 in. apart, and the recorder orifice rims are approximately 9 in. above the nonrecorder orifice rims. Records of wind movement are not available. It is assumed that the observers at the two substations have serviced the gages according to

TABLE 1.—*Comparison of 8-in. orifice gages*

Year (Apr.—Oct.)	Danville			Farmer City		
	Non-recording gage (B) (inches)	Recording gage (D) (inches)	Recording gage ÷ nonrecording gage (percent)	Non-recording gage (B) (inches)	Recording gage (D) (inches)	Recording gage ÷ nonrecording gage (percent)
1958	30.90	29.36	95.0			
1960	22.66	20.95	92.5			
1961	27.42	25.48	92.9			
1962	32.32	31.65	97.9	14.83	14.04	94.7*
1963	14.40	13.29	92.3	14.13	13.49	95.5
1964	21.44	19.87	92.7	25.96	25.97	100.0
1965	32.94	30.92	93.9	28.38	28.27	99.6
1966	18.50	16.98	91.8	21.99	21.64	98.4
1967	10.77	9.85	91.5*	11.22	10.08	89.8*
Totals	211.35	198.35	93.8	116.51	113.49	97.4

*Partial record. Capital letters in parentheses refer to gages in figure 1.

Instructions for Climatological Observers by the U.S. Weather Bureau (1962); i.e., the nonrecording gage was emptied after each daily reading, and the recording gage chart was changed within 24 hr after each rain or once each week when no rain occurred. Since all data used in the study were collected during the warmer half year, it is assumed that the bucket of the recording gage was emptied at the time the chart was changed.

Comparison of the paired gages has been restricted to the warm months, April–October, so that only rainfall was measured. For every season except one, the nonrecording gage at both stations caught more rain than the recording gage (table 1). The difference in total catch between gages at Farmer City is 2.5 percent as compared with a 6 percent difference at Danville. Probably this is due to the differences in exposure at the two sites. Some of the difference between gage types occurs because of the difficulty in reading amounts less than 0.05 in. from the recording chart after the chart has been in use for 1 or more days. The chart rotates once each 24 hr and retraces over the same line if no rain has occurred during that time.

Since the two instruments are compared for the same interval, where necessary, the recording gage catch was corrected to coincide with the reporting period of the nonrecording gage at either the beginning or end of the warm season.

3. COMPARISON OF NONRECORDING AND STEVENS RECORDING GAGES

The decrease in catch of rainfall is not limited to the standard weighing-type gages. The shape of the housing of the Stevens Q–12 series of weighing-bucket recording gages (fig. 1C) is such that the orifice is the termination of a truncated conical section similar to the Sacramento storage gage and the Fischer-Porter recording gage. A Stevens gage and a standard nonrecording gage were exposed within 6 ft of each other within a chain-link wire enclosure on the Engineering Campus of the University of Illinois for a number of years. The gage orifice of the Stevens gage was 11 in. above the nonrecording orifice rim. During 4.5 of those years as shown in table 2, the

TABLE 2.—*Comparison of nonrecording and Stevens recording gages*

Year (Apr.-Oct.)	(B) Nonrecording gage (inches)	(C) Stevens gage (inches)	Stevens nonrecorder (percent)
1959	21.74	19.90	91.5
1960	24.03	22.16	92.2
1961	29.75	29.04	97.6
1962	26.40	25.54	96.7
1963*	10.03	9.11	90.8
Totals	111.95	105.75	94.5

*Partial record. Letters in parentheses refer to the gages in figure 1.

Stevens gage caught only 94.5 percent of the catch in the nonrecording gage during the warm months of 1959–1963. The record for 1963 is incomplete since the nonrecording gage was removed in August of that year. During an individual warm season, the recording gage measured as low as 91 percent of the nonrecording gage's measurement.

4. COMPARISON OF DIFFERENT ORIFICE SIZES

Another set of data for evaluating the effect of the recording gage housing on the catch is available from the records of the East Central Illinois Network of the Illinois State Water Survey. This network of 49 Universal Recording Rain and Snow Gages has been in continuous operation since 1955 in an area of very flat prairie farmland. The gage sites tend to have open exposures since the gages were located along rural roads away from buildings and trees. The 49 gages were fitted with 12.648-in. orifices in 1955 and were operated with this homogeneous gage type until 1965 when the 25 odd-numbered gages (fig. 2) were fitted with the standard 8.0-in. tops. A gage with a 12.648-in. top (fig. 1E) has a profile approximating a right cylinder and, therefore, no sloping shoulder. These larger tops result in a precipitation measurement magnified 2.5 times more than the standard 8.0-in. tops. A disadvantage of the larger top is that the maximum amount of precipitation that the gage will record is reduced from 12.00 in. to 4.80 in.

Table 3 lists the average warm season rainfall for the odd-numbered and even-numbered gages for the years 1955–1958, although all gages had identical tops during this period. In 1955 and 1956, the odd-numbered gages averaged 1 to 2 percent less rainfall than the even-numbered gages. However, the averages were reversed in the other 2 yr, resulting in 4-yr totals that were equal. Thus, exposure differences between the odd- and even-numbered gages are insignificant; and, in the mean, the average catch of the two groups of gages should be equal.

Table 4 gives the values from the two sets of grouped gages for the 1965–1967 period when the odd-numbered gages had 8-in. tops. The odd-numbered gages always averaged less precipitation over the period of comparison with the average difference between the groups of 2.6 percent.

The effectiveness of various-sized areas and shapes of the orifices of raingages has been the concern of researchers

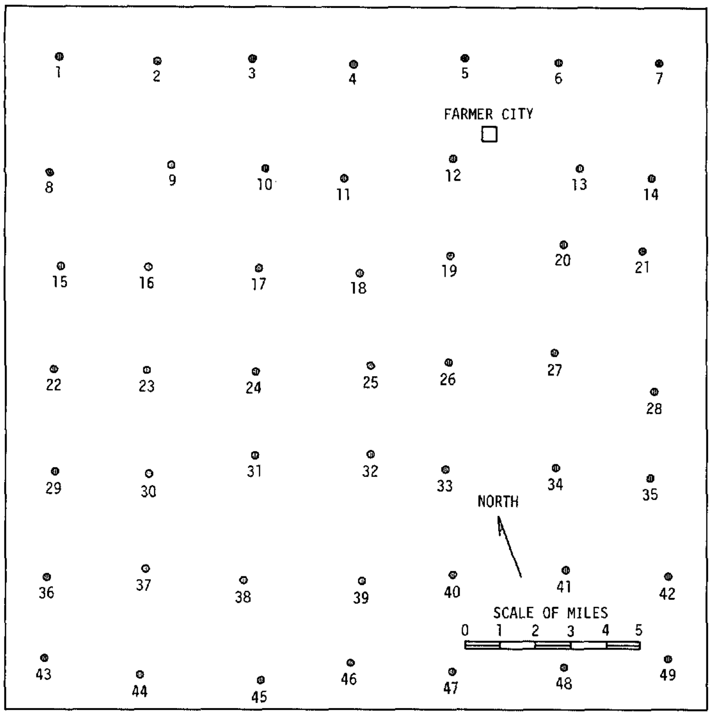

FIGURE 2.—Illinois State Water Survey, East Central Illinois Network.

TABLE 3.—*Average catch of precipitation for April–October through 12-in. receivers*

Year	No. of storms	(E) Odd-numbered (inches)	(E) Even-numbered (inches)	Odd-even (percent)
1955	48	18.62	18.75	99.3
1956	65	15.08	15.36	98.2
1957	77	31.47	31.15	101.0
1958	93	24.95	24.86	100.4
Totals		90.12	90.12	100.0

Letters in parentheses refer to gages in figure 1.

(Kurtyka, 1953) in raingage desig since the 1800'ns. Usually, the experiments conducted were confused by the question of the height at which the gage orifice was exposed and the proximity of the internal funnel to the orifice. The later work of Denison (1941) and Huff (1955) illustrates the latter point. Denison and Huff were careful to expose their test gages with all orifices at the same height where possible. However, the U.S. Weather Bureau standard nonrecording gages used by Denison and Huff (and in the substation portion of this study) have a 45° funnel as close as 2 in. below the orifice rim assuring a reduction in catch by splash-out (Middleton, 1943). The comparison gages either had no funnel or the orifice geometry was such that splash-out was inhibited.

TABLE 4.—*Average catch of precipitation for April–October through 8- and 12-in. receivers*

Year	No. of storms	(D) 8-in. odd-numbered (inches)	(E) 12-in. even-numbered (inches)	Odd-even (percent)
1965	72	27.24	27.61	98.7
1966	60	22.21	23.10	96.1
1967	85	21.33	21.99	97.0
Totals		70.78	72.70	97.4

Letters in parentheses refer to gages in figure 1.

5. CONCLUSIONS

The results of these studies show that gages with sloping shoulders below the gage orifice collected 2–6 percent less rainfall than gages with the shape of a right cylinder. Since Eichmeier (1965) found a greater reduction in catch for the gage with the shortest stack extension, it may be assumed that the seriousness of the catch reduction will depend upon the proximity of the sloping surface to the orifice as well as the exposure of the gage to the wind. At the present time, most recording gages used in the United States have the sloping shoulder. Thus, serious consideration should be given to future design of gage housings to avoid the effects of gage shape on the catch of the gage.

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