ナイロン網地1反の空中重量

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Practical Epuations for the Weight in Air of One Strip of Nylon Netting[*1]

Tadanobu Machii[*2] and Yukio Nose[*3]

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Equations for the weight of netting are very important in designing fishing gears and in practical work, but there are very few studies on the subject. In this study, we developed equations for the weight in air of one strip of netting based on the Netting Weight Table. Whereas in the previous study, we derived them from a single mesh measurements. The material used is nylon multifilament and English knot. One strip of netting is equivalent to 100 fathoms' length with a depth of 100 meshes. Using the relations obtained in the previous study, we determined the constants for one strip of netting. The equations for the weight of netting (W) can be expressed with kg-cm units, as $W=n\{1+2/5(\sqrt{n}/L_m)\}$ in $3\leqq n\leqq 51$ and $W=1.1\cdot n\cdot\{1+2/5(\sqrt{n}/L_m)\}$ in $60\leqq n\leqq 180$, where n is the number of yarns and L_m is the mesh size. Verifying the results, we found that the equations fitted very well with the values of the Netting Weight Table.

Equations for the weight of netting are acquiring greater importance in designing fishing gears and for practical use at field works.

Regarding this subject, we find only the studies of Nagamine[1)] and Miyamoto[2)] for the weight in the air of natural fibers and Iitaka[3)] for the weight in the water of synthetic fibers.

In the previous study,[4)] we determined the relation of the weight in the air for one strip of English knot nylon netting, which was derived from the relations of a single mesh and the measurements of netting.

The purpose of this study is to determine equations based on the relation of the previous study, from the Netting Weight Table and to verify the adequacy of the equations obtained in comparison with the values of the Netting Weight Table. We also discuss the lateral effect caused by the length of knot.

Materials and Methods

Although a netting is made with the same standard, there is a slight difference in the weight among fishing net manufactures. This difference depends on the twisting degree given for the legs of netting in each manufacturer. In this study, we used the Netting Weight Table considering manufacture "A" as standard. The material is nylon multifilament, English knot, 210 denier and three strand twine from 3 to 180 yarns.

One strip of netting is defined in Japan by 100 "ken"[*4] long and 100 meshes deep, but we used 100 fathoms' length, because this unit is recognized throughout the world. A single mesh consists of two legs and one knot, and the mesh size is the length of two legs and two knots. The units used are kilograms for weight and centimeters for length.

The weight in the air for one strip of nylon netting (W) was expressed by the relation in the previous study as

$$W=C_1\cdot n+C_2\left(\frac{n^{3/2}}{L_m}\right) \qquad (1)$$

where L_m is the mesh size, n is the number of yarns, and C_1 and C_2 are the constants. Also, W, n and L_m are known variables taken from the Netting Weight Table.

From the equation (1), we can determine the constants C_1 and C_2.

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[*2] Department of Fishing Science & Technology, Tokyo University of Fisheries, Konan 4–5–7, Minato, Tokyo 108, Japan (町井紀之: 東京水産大学漁業生産学科).

[*3] Department of Fisheries, Faculty of Agriculture, The University of Tokyo, Yayoi 1–1–1, Bunkyo, Tokyo 113, Japan (能勢幸雄: 東京大学農学部水産学科).

[*4] 100 ken=151.5 m, Japanese traditional fishing unit.

Results and Discussion

Determination of Equations and Their Verification

Table 1 shows the results obtained from the constants C_1 and C_2 for a given n. Both C_1 and C_2 should take theoretically the definite values. Though C_2 can be considered nearly as a unitary value, a tendency is observed in C_1 to increase for a given increase in n.

Consequently C_1 can not be treated as a unitary value capable of covering an overall range of n. In order to solve the practical side of this problem, we devided the range of n into two cases; *i.e.*, $3 \leqq n \leqq 51$ as a body netting and $60 \leqq n \leqq 180$ as a selvage netting.

In order to find the best values within the classified range of n, we carried out simulation tests for C_1 and C_2 to obtain high correlation values. The results obtained are $C_1 = 1.0$ and $C_2 = 0.40$ in $3 \leqq n \leqq 51$, and $C_1 = 1.1$ and $C_2 = 0.44$ in $60 \leqq n \leqq 180$.

From the constants obtained, the equations for the weight of one strip of netting can be expressed as follows;

$$W = n \cdot \left(1 + \frac{2}{5}\frac{\sqrt{n}}{L_m}\right) \quad (3 \leqq n \leqq 51) \qquad (2)$$

and

$$W = 1.1 \cdot n\left(1 + \frac{2}{5}\frac{\sqrt{n}}{L_m}\right) \quad (60 \leqq n \leqq 180) \quad (3)$$

In order to verify the equations, we calculated with the equation (2) four examples of L_m from 3.49 to 24.1 cm in $3 \leqq n \leqq 51$, and with the equation (3) five examples from 4.45 to 8.89 cm in $60 \leqq n \leqq 180$. About the range of L_m, the former covers all the body netting, the latter includes practically the selvage netting range.

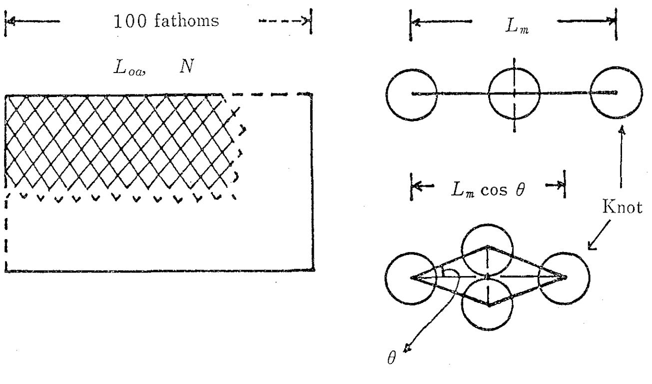
Table 1. Constants obtained from the Netting Weight Table of Nylon*

n	L_m (cm)		No. of data	Constants	
	Min.	Max.		C_1	C_2
3	0.953	24.1	49	0.955	0.384
6	//	//	//	0.947	0.406
9	//	//	//	0.972	0.396
12	//	//	//	0.991	0.434
15	1.27	//	48	0.984	0.406
18	1.59	//	47	0.999	0.411
21	//	//	//	0.945	0.502
24	1.90	//	46	0.956	0.476
27	2.22	//	45	0.978	0.459
30	//	//	//	0.982	0.456
36	//	//	//	0.984	0.491
45	2.86	//	43	1.07	0.421
51	3.49	//	41	1.06	0.455
60	//	//	//	1.06	0.507
75	//	//	//	1.01	0.481
90	//	//	//	1.14	0.465
120	5.08	//	36	1.14	0.429
150	//	//	//	1.16	0.390
180	//	//	//	1.21	0.372

* 100 fathoms' long and 100 meshes deep in the case of English knot.

The comparison of the values between the Netting Weight Table (*Tab.*) and the calculation by the equations (*Cal.*) are shown in Table 2, where R (%) ($\{(Cal.-Tab.)/Tab.\} \times 100$) is the error by *Cal.* as compared to *Tab.*.

Regarding R in Table 2, in $3 \leqq n \leqq 51$, when n is a fixed value, R seems to vary inversely according to the increment of L_m, and when L_m is a fixed value, R increases at both extremes of n. In $60 \leqq n \leqq 180$, the difference of R can not be clearly observed depending on L_m (n: fixed value).



One strip of netting A single mesh.

Fig. 1. Lateral effect caused by the length of knots. L_{oa}: Lateral stretched length of 100 fathoms, N: Total lateral number of mesh within 100 fathoms, L_m: Mesh size, and θ: Angle based on the lateral effect.

Table 2. Comparisons of the weight in the air for one strip of netting* between Netting Weight Table values and calculated values

Body Netting

L_m	3.49 cm 1 3/8″			7.62 cm 3″			11.7 cm 4 5/8″			24.1 cm 9 1/2″		
n	*Tab.* kg	*Cal.* kg	R %	*Tab.* kg	*Cal.* kg	R %	*Tab.* kg	*Cal.* kg	R %	*Tab.* kg	*Cal.* kg	R %
3	3.48	3.60	3.36	3.14	3.27	4.17	3.03	3.18	4.78	2.85	3.09	8.36
6	7.35	7.68	4.47	6.41	6.71	4.73	6.25	6.55	4.85	6.06	6.24	2.97
9	11.87	12.09	1.86	10.00	10.42	4.13	9.67	9.92	2.61	9.36	9.45	0.90
12	16.99	16.76	−1.37	14.16	14.18	0.13	13.43	13.42	−0.13	12.71	12.69	−0.20
15	21.44	21.66	0.98	17.87	18.05	1.00	16.89	16.98	0.53	15.84	15.96	0.81
18	27.08	26.75	−1.23	21.92	22.01	0.41	20.83	20.60	−1.08	19.09	19.27	0.90
21	32.87	32.02	−2.59	25.80	26.05	0.98	24.19	24.28	0.38	22.44	22.60	0.68
24	38.44	37.47	−2.53	29.68	30.17	1.67	28.09	28.01	−0.31	25.97	25.95	−0.08
27	44.79	43.07	−3.84	34.27	34.37	0.27	32.22	31.78	−1.37	29.45	29.33	−0.43
30	50.88	48.82	−4.04	38.68	38.63	0.15	36.14	35.60	−1.51	32.94	32.72	−0.45
36	66.19	60.74	−8.23	48.18	47.34	−1.75	45.08	43.36	−3.81	39.68	39.58	−0.24
45	85.51	79.58	−6.94	63.46	60.85	−4.12	59.38	55.29	−6.90	51.98	50.00	−1.92
51	104.2	92.72	−11.0	74.65	70.12	−6.07	68.43	63.41	−7.34	58.32	57.04	−2.19

Selvage Netting

L_m	4.45 cm 1 3/4″			5.08 cm 2″			6.35 cm 2 1/2″			6.99 cm 2 3/4″			8.89 cm 3 1/2″		
n	*Tab.* kg	*Cal.* kg	R %	*Tab.* kg	*Cal.* kg	R %	*Tab.* kg	*Cal.* kg	R %	*Tab.* kg	*Cal.* kg	R %	*Tab.* kg	*Cal.* kg	R %
60	117.2	112.0	−4.39	108.6	106.3	−2.15	99.6	98.6	−1.37	96.5	95.3	−1.21	88.8	89.0	0.21
72	139.0	139.7	0.53	129.6	132.1	1.94	117.7	121.5	3.40	114.4	117.7	2.88	103.4	109.4	5.81
75	145.9	146.8	0.60	135.7	138.8	2.23	123.9	127.5	2.95	120.5	123.4	2.44	109.0	114.7	5.17
90	189.8	183.5	−3.30	171.7	173.0	0.76	165.0	158.2	−4.13	160.5	152.8	−4.79	148.4	141.3	−4.82
96				186.7	187.1	0.20	178.3	170.8	−4.20	173.4	164.9	−4.91	160.6	152.2	−5.27
120				245.4	245.9	0.19	223.9	223.1	−0.38	217.8	214.8	−1.38	201.5	197.1	−2.18
150				312.2	324.1	3.82	284.5	292.3	2.75	276.9	280.7	1.37	256.3	255.9	−0.13
180				390.9	407.2	4.16	356.7	365.3	2.42	345.0	350.1	0.91	320.9	317.8	−0.95

* 100 fathoms' long and 100 meshes deep in the case of English knot nylon netting

As a result, the equations (2) and (3) fitted very well with the values of the Netting Weight Table.

Lateral Effect Caused by the Length of Knots

When we assume that the total lateral number of mesh within 100 fathoms (N) and the mesh size (L_m) are known variable, there are two criteria in the lateral stretched length of one strip of netting (L_{oa}) as shown in Fig. 1.

One is the length (L_{oa_1}) from the criteria in the previous study, without consideration to lateral effect caused by the length of knots (called here the lateral effect). The other is the length (L_{oa_2}) from the Netting Weight Table in this study, taking into account the lateral effect.

So, the relation between L_{oa_2} and L_{oa_1} can be written as

$$\frac{L_{oa_2}}{L_{oa_1}}=\cos\theta \qquad (4)$$

where θ is the angle based on the lateral effect. As shown by the equation (4), when taking L_{oa_1} as standard, L_{oa_2} is shorter than L_{oa_1} with the increment of θ.

On the other hand, when we assume that L_{oa} and L_m are known variables, there are also two criteria in the N as shown in Fig. 1.

One is the total lateral number of mesh (N_1), from the criteria in the previous study, without consideration to the lateral effect. The other is the total lateral number of mesh (N_2), from the Netting Weight Table in this study, with consideration to the lateral effect.

So, the relation between N_1 and N_2 can be written as

$$\frac{N_2}{N_1}=\frac{1}{\cos\theta} \qquad (5)$$

The equation (5) shows, when taking N_1 as standard, N_2 is larger than N_1 with the increment of θ.

From the previous study W could be expressed as

$$W=n\cdot\left(1+\frac{1}{3}\frac{\sqrt{n}}{L_m}\right) \quad (6\leqq n\leqq 180) \qquad (6)$$

In order to verify the lateral effect, we compared difference of values between the *Tab.* and *Cal.* by the calculation of the equation (6) as shown in Table 3, where E (%) ($\{(Tab.-Cal.)/Cal.\}\times 100$) is the lateral effect.

Table 3. Lateral effect E (%) caused by the length of knots for one strip of netting*

Body Netting

L_m	3.49 cm	7.62 cm	11.7 cm	24.1 cm
n	1 3/8″	4″	4 5/8″	9 1/2″
3	−0.52	−2.64	−3.69	−7.29
6	−0.67	−3.54	−2.66	−2.25
9	2.51	−1.78	−1.04	−0.10
12	6.38	2.47	1.86	1.07
15	4.34	1.87	1.41	0.23
18	7.06	2.71	3.24	0.18
21	8.87	2.34	1.89	0.49
24	9.11	1.84	2.71	1.34
27	10.9	3.42	3.95	1.76
30	11.4	4.02	4.21	2.07
36	16.9	6.01	6.94	1.78
45	15.8	9.03	10.8	5.70
51	21.5	11.5	11.5	4.07

Selvage Netting

L_m	4.45 cm	5.08 cm	6.35 cm	6.99 cm	8.89 cm
n	1 3/4″	2″	2 1/2″	2 3/4″	3 1/2″
60	23.6	20.0	18.0	17.4	14.7
72	18.0	15.6	13.1	13.1	9.0
75	18.0	15.4	13.6	13.7	9.7
90	23.3	17.6	22.4	22.8	21.6
96		18.4	22.6	23.1	22.3
120		19.0	18.5	19.2	19.0
150		15.4	15.4	16.5	17.1
180		15.5	16.3	16.9	18.6

* 100 fathoms' long and 100 meshes deep in the case of English knot nylon netting

The length of one knot (L_k) is proportional to $\sqrt{n}$, and L_k/L_m is proportional to $\sin\theta$. However, the lateral effect is clearly found in Table 3, according to the increment of n and/or with the decrement of L_m.

As mentioned above, there is the difference in the criteria between the previous study and this study. This is the reason why the constant C_1 could not be treated as a unitary value in this study.

In conclusion, we can apply the equations (2) and (3) for full scale net making, including the lateral effect for the calculations. The equation (6) can be used for the calculation necessary to make model nets, excluding the lateral effect in the calculations.

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