

, ()

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.

1.

2.

3.

4.

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1.

.

1.

2.

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국문 요약

(*Reticulitermes speratus kyushuensis* Morimoto)

(, ,)

)

(*R. speratus kyushuensis* Morimoto)

Coptotermes formosanus Shiraki

(4)

Reticulitermes speratus Kolbe

(-4)가

30 (90% RH)

. 10 30 (90% RH

)

95%

, 32

52% RH(30) 70% RH(30)

(100%)

84% RH

(97%)

(87%)

(14%)

34.5%(55

19 , 3)

가

2001

4

11

7

8

(2000 11 ~ 2001 3)

가

가

가

(Integrated Pest Management, IPM)

가

: , , , , , , , IPM

머리말

가
Reticulitermes speratus (subspecies) *Reticulitermes speratus*
kyushuensis Morimoto가 ([1], [2]).
 (minerals) , ,
 (methane) ([3]).
 2,800 (colony)
 , () 가 , (king)
 (queen)
 가 (Hymenoptera) .
 가 (reproductive)
 (workers), (nymphs pseudoworkers), (soldiers),
 (larvae), (egg) (1). 2

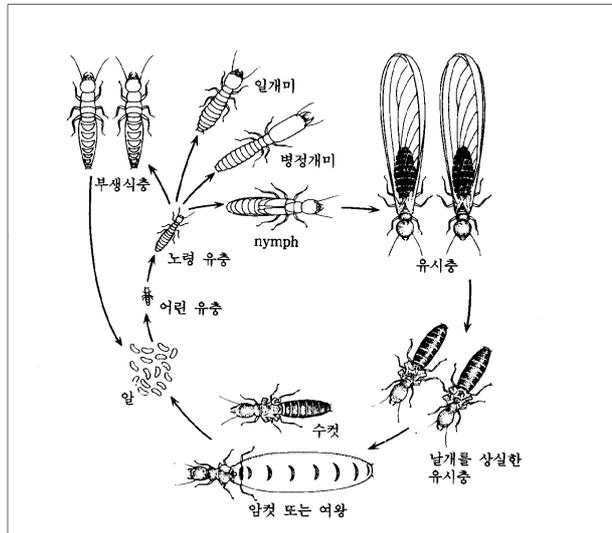
2

([4]).

가 ,

가 . ,

, ,



< 1> Cast development of *Reticulitermes* spp.

(f o r a g i n g)



(A)



(B)



(C)



(D)

- < 2> Comparison with external morphology on termite(Rhinotermitidae)
 (A) Worker of *Reticulitermes speratus kyushuensis* Morimoto (Korea)
 (B) Soldier of *Reticulitermes speratus kyushuensis* Morimoto (Korea)
 (C) Soldier of *Reticulitermes speratus* Kolbe (Japan)
 (D) Soldier of *Coptotermes formosanus* Shiaki (Japan)

[5], [6]).

가 가 ([7]). 가
 가 *Coptotermes formosanus* Shiraki 22 가
 , 476 *Reticulitermes speratus*
 (subspecies) *R. speratus kyushuensis* Morimoto 1
 (2).

가
 (*R. speratus kyushuensis* Morimoto) . ,

가

한반도의 기후 특성

1.

11.3 ~ 14.8 (, , , , , , ,), (, , , , , , ,), (, , ,) . 14 가 16 (14.8.) , 가 (11.3) .

< 1> The averages of yearly temperatures and monthly temperatures among 4 years on 16 cities of Korea

Location	Yearly temp ()	Monthly temp.()											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	12.8	-2.1	0.9	6.4	13.1	18.6	22.5	25.4	25.3	21.4	14.5	6.9	0.7
2	12.1	-2.6	-0.4	5.3	12.2	17.7	21.9	25.2	24.9	20.8	13.7	6.0	0.1
3	11.3	-4.4	-1.2	5.1	12.0	17.9	22.1	25.1	24.4	19.5	12.1	4.4	-1.7
4	13.2	0.2	2.6	7.6	13.4	17.3	21.6	24.7	24.2	19.8	15.2	8.6	3.2
5	12.7	-1.6	0.7	6.4	13.3	18.5	22.4	25.4	25.1	20.6	13.9	6.5	0.8
6	13.0	-0.9	1.3	6.9	13.5	18.6	22.5	25.2	25.2	21.1	14.3	7.0	1.5
7	11.7	-2.0	-0.5	4.4	11.2	16.8	21.0	24.6	24.6	20.3	13.5	6.1	0.5
8	13.7	0.5	2.0	6.9	13.5	18.6	22.6	25.9	25.9	21.8	15.2	8.1	2.6
9	12.9	0.2	1.5	6.0	12.1	17.1	21.4	24.9	25.2	21.4	15.2	8.1	2.5
10	13.7	0.9	2.6	7.3	13.6	18.6	22.3	25.3	25.4	21.6	15.4	8.4	3.2
11	14.6	3.1	4.7	8.8	13.9	17.9	21.2	24.2	25.5	22.4	17.3	10.9	5.7
12	14.2	0.9	3.4	8.7	14.6	19.3	23.2	25.8	25.9	21.6	15.7	8.7	3.1
13	12.7	1.2	3.1	7.4	12.4	16.2	19.6	22.9	23.2	19.3	14.8	8.8	3.9
14	14.8	3.4	5.0	9.1	14.0	17.7	21.3	24.5	25.9	22.5	17.4	10.9	5.8
15	13.4	0.5	2.5	7.4	13.3	18.1	22.2	25.3	25.6	21.3	14.6	7.4	2.2
16	14.8	3.6	5.5	9.5	14.1	17.6	20.9	24.2	25.5	22.2	17.4	11.4	6.0

Location 1: Seoul, 2: Suwon, 3: Chuncheon, 4: Gangneung,
 5: Cheongju, 6: Daejeon, 7: Seosan, 8: Jeonju,
 9: Gunsan, 10: Gwangju, 11: Yeosu, 12: Daegu,
 13: Ulsan, 14: Tongyeong, 15: Jinju, 16: Busan.

14 (14.8), (14.8), (14.6), (14.2) , 13 (13.7), (13.7), (13.4), (13.2), (13.0) . 12 (12.9), (12.8), (12.7), (12.7), (12.1) , 11 (11.7), (11.3) . (14.8), (14.6) (14.8) . 가 (25.9), (25.9) (25.9) , 가 (-4.4) . 16 가 7 8 , 가 1 (1).

2.

13.6 ~ 16.5 가 . 가 0 30 , (, ,) 5 . 25 가 가 7 8 , 가 1 , 가 가 8 , 가 1 2 . 가 가 9 (16.5) , 가 (13.6) . (16.5), (15.9) (15.4)가 , 13.6 ~ 16.5 . 가 16 (16.5) , 15 (15.9), (15.4) (15.0) . 14 (14.6), (14.6) (14.1) ,

13 (13.6) (13.6) . 가 가
 (26.9) , 가 (1.1) . 가 가
 8 , 가 1 2 , 0
 (2).
 9 , 1 2
 가 1.8 ~ 4.4 , 3 . 4 7
 , 8 12 가 0.8 ~ 4
 9 . 가

< 2> The averages of yearly soil temperature and monthly soil temperature among 4 years on 9 cities of Korea

Location	Yearly Soil temp. ()	Monthly Soil temp.()											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	13.6	2.2	1.8	5.2	11.3	14.6	21.5	24.4	25.6	23.2	18.0	10.7	5.1
2	14.6	4.1	3.8	7.0	12.3	17.0	21.4	24.4	25.3	23.1	18.2	11.7	6.5
3	13.6	1.7	1.1	3.7	10.9	17.0	21.8	24.9	25.8	23.3	17.7	10.2	4.7
4	14.1	3.6	3.4	6.7	11.4	15.9	20.3	23.2	24.6	22.3	18.2	12.4	7.3
5	14.6	3.8	3.2	6.6	11.8	17.0	21.5	24.1	25.6	23.6	18.9	12.3	6.9
6	15.0	2.6	2.6	7.6	13.3	19.0	23.4	25.9	26.9	24.3	18.6	11.1	5.3
7	15.9	6.5	6.2	8.8	13.2	17.2	21.2	23.7	25.7	24.1	20.3	14.7	9.6
8	15.4	4.2	4.6	8.2	13.4	17.9	22.2	24.8	26.7	24.0	19.4	12.7	7.1
9	16.5	6.7	6.4	9.4	14.1	18.0	21.8	24.8	26.6	24.8	20.5	15.0	9.7

Location 1: Seoul, 2: Suwon, 3: Chuncheon, 4: Gangneung,
 5: Cheongju, 6: Daejeon, 7: Yeosu 8: Jinju
 9: Busan

11 , 가 12
 . 9 , 8 , , 6
 가 .

3.

1251.3 ~ 1708.3 mm , 16
 (1708.3 mm), (1682.9 mm) (1607.3 mm) ,

(1251.3 mm), (1251.7 mm) .
 , 가
 (555.9 mm) , 가 (16.2 mm) .
 5 (, , , ,) 100 mm 7
 9 (3) 4 (, , ,) 4 9 (6
) .
 (3).

< 3> The averages of yearly rainfall and monthly rainfall among 4 years on 16 cities of Korea

Location	Yearly rainfall (mm)	Monthly rainfall(mm)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	1493.2	33.4	22.5	19.9	84.4	63.9	110.7	375.9	555.9	136.8	43.2	30.5	16.2
2	1285.6	35.5	24.6	20.6	91.9	55.0	137.9	361.3	343.6	124.3	46.0	26.4	18.6
3	1326.7	39.4	18.8	23.3	79.9	68.4	123.2	314.5	430.2	129.2	48.2	29.5	22.1
4	1597.1	76.4	47.9	37.0	76.6	75.4	106.6	164.3	429.2	335.4	111.9	95.9	40.8
5	1251.3	42.6	26.4	21.6	98.4	69.2	161.8	281.2	325.6	124.4	49.6	25.9	24.7
6	1416.0	48.0	36.3	27.9	115.3	83.6	178.6	341.6	336.4	143.5	51.3	28.0	25.5
7	1308.2	43.3	22.3	17.1	104.1	90.7	171.8	262.3	357.7	143.1	45.8	30.7	19.3
8	1411.6	48.3	33.1	36.1	123.9	73.2	204.7	347.4	292.9	135.6	51.9	32.6	31.9
9	1292.7	49.9	29.3	25.5	118.1	74.5	160.5	254.9	347.3	110.7	56.7	32.4	33.1
10	1523.4	56.2	41.3	41.0	105.4	77.7	175.6	334.3	411.6	169.8	44.1	35.4	31.2
11	1511.9	27.5	30.8	52.5	126.3	126.3	226.8	335.8	315.3	180.3	38.8	29.0	22.9
12	1251.7	29.3	26.1	31.2	67.3	110.6	152.0	271.4	292.3	192.0	38.3	25.0	16.4
13	1708.3	81.6	30.5	27.1	66.4	89.4	106.5	139.8	294.3	268.2	83.0	86.6	33.2
14	1607.7	42.3	32.0	65.2	141.3	132.6	189.4	356.1	360.9	157.8	66.1	35.9	28.2
15	1682.9	42.2	36.6	49.3	121.5	138.5	197.1	356.8	431.2	215.3	42.7	30.4	21.3
16	1306.4	48.6	29.3	62.2	181.2	167.7	199.9	392.8	361.1	124.3	71.5	38.5	31.4

Location 1: Seoul, 2: Suwon, 3: Chuncheon, 4: Gangneung,
 5: Cheongju, 6: Daejeon, 7: Seosan, 8: Jeonju,
 9: Gunsan. 10: Gwangju, 11: Yeosu, 12: Daegu,
 13: Uljin, 14: Tongyeong, 15: Jinju, 16: Busan.

4. (,)
 (, ,)
 (RH)가 16 (73.1% RH) (72.1% RH)
 (59.1% RH) (59.5% RH)
 (,) 가 가
 (86.5% RH) 가 (44.8% RH)
 가 가 7 8 , 가 2 , 3 , 4
 12 (4).

< 4> The averages of yearly relative humidity and monthly relative humidity among

4 years on 16 cities of Korea

Location	Yearly RH (% RH)	Monthly RH(% RH)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	63.0	62.3	58.3	54.8	54.8	61.5	66.8	74.5	76.0	67.0	62.5	59.0	56.5
2	64.6	62.8	61.8	58.5	57.8	64.3	68.5	75.3	76.0	68.8	65.0	61.8	57.8
3	68.4	69.0	63.5	57.0	55.0	63.5	68.3	76.3	79.5	76.0	75.0	69.0	66.3
4	59.1	52.0	48.3	48.0	50.3	65.3	67.0	73.0	77.3	74.0	59.0	50.8	44.8
5	64.8	67.3	60.8	54.8	51.5	59.5	66.0	74.0	75.5	71.5	67.3	64.5	63.3
6	66.9	68.0	61.3	56.5	54.5	63.3	68.8	77.3	78.0	73.8	70.5	67.3	65.3
7	73.1	72.5	70.3	67.5	65.0	71.5	75.0	81.8	82.0	76.8	73.0	71.5	70.5
8	67.2	68.0	63.0	60.3	56.3	65.0	69.3	76.3	75.8	72.5	67.5	65.8	64.5
9	72.1	68.8	66.3	65.8	65.5	74.3	78.5	83.3	81.8	77.0	71.3	66.5	65.5
10	65.7	66.0	58.8	57.0	57.0	64.0	68.3	76.8	76.8	70.8	66.0	63.8	62.5
11	62.7	54.0	51.0	54.8	61.3	69.5	74.0	81.5	76.5	68.8	58.5	54.3	49.8
12	59.5	54.5	47.5	46.3	49.5	59.0	63.8	73.8	74.0	71.3	64.0	57.8	51.5
13	65.5	52.8	51.0	54.0	60.0	72.5	78.0	81.3	83.8	80.0	68.5	58.0	47.8
14	65.1	54.8	50.8	55.3	62.5	72.0	76.0	83.3	79.5	73.0	64.8	59.5	50.5
15	67.2	59.5	54.8	56.3	60.5	68.5	72.0	80.0	79.5	75.8	72.3	67.3	59.0
16	65.0	51.5	46.0	55.0	63.8	73.8	78.5	86.5	82.3	74.3	64.3	56.5	46.8

Location 1: Seoul, 2: Suwon, 3: Chuncheon, 4: Gangneung,
 5: Cheongju, 6: Daejeon, 7: Seosan, 8: Jeonju,
 9: Gunsan. 10: Gwangju, 11: Yeosu, 12: Daegu,
 13: Uljin, 14: Tongyeong, 15: Jinju, 16: Busan.

흰개미의 선호도 관찰

1.

(1)

(*R. speratus kyushuensis*)

38.5×32 cm)

2

(∅34×∅

가

(∅9.0cm, 1.5cm)

(2)

(20×10×10cm)

(∅20cm, Whatman No. 1) 2

4

가

100

가

1

10 , 15 , 20 , 25 , 30 , 32 , 35 ,

(RH)가 90%

([8]).

2

50

2

(consecutive weight)

,

1

30

1.50%

, 1

0

35

0.17%

. 10

30

가

가

, 32

35

20

(RH) 90%

30

10 , 15 , 20 , 25 , 30

98.0%, 96.5%, 94.5%, 98.5%, 96.0%

. 32

39.0%

35

가

(5).

10 ~ 3

0 , 32

90% RH 30
32 가 가

< 5> Mean survival and consumption rate of termite held at different temperature(90% RH over)

Temp ()	Consumption			Survival		
	Before (g)	After (g)	Rate (%)	Before (No.)	After (No.)	Mean (%)
10	5.99	5.98	0.17	200	196	98.0
15	5.94	5.92	0.34	200	193	96.5
20	6.00	5.94	1.00	200	189	94.5
25	5.95	5.89	1.01	200	197	98.5
30	6.01	5.92	1.50	200	192	96.0
32	5.72	5.69	0.52	200	78	39.0
35	5.94	5.93	0.17	200	0	0.0

(3)

(20×10×10cm) 2 4
가 100
(saturated salt solution) 30
가 1 RH
52%, 70%, 84% ,
2
50 2
, 1 84% RH(30) (2.04%) ,
52% RH(30) (0%) . 52% RH(30) 84%
RH(30) 가 가
52% RH(30) 70% RH(30) 0%

, 84% RH(30) 97.0% 가
 (6). 50% RH(30)
 , 70% RH(30) 가 가
 . 84% RH(30)
 84% RH(30)

< 6> Mean survival and consumption rate of termite held at different relative humidity (30)

R. H. (%)	Consumption			Survival		
	Before(g)	After(g)	Rate(%)	Before(No.)	After(No.)	Mean(%)
52	5.81	5.81	0.00	200	0	0.0
70	5.82	5.73	1.55	200	0	0.0
84	5.87	5.75	2.04	200	194	97.0

(4)

(20×10×10 cm) 가
 90% RH 가 .
 , 100 30
 2 . 4 (
 (*Paulownia coreana*), 0.30; (*Pinus densiflora*), 0.50; (*Fraxinus
 rhynchophylla*), 0.77; (*Betula schmidtii*), 0.93) .
 50 2 , 2
 ([8]).
 , 2 30 , 90% RH (*Pinus densiflora*)
 , (*Paulownia coreana*), (*Fraxinus
 rhynchophylla*) (*Betula schmidtii*) .
 (7.88%) , (3.10%)
 가 (87%) (13.5%) (7).

< 7> Mean survival and feeding rate of termite held at different wood (30 , 90% RH)

Wood	Consumption			Survival		
	Before(g)	After(g)	Rate(%)	Before(No.)	After(No.)	Mean(%)
1*	10.33	10.01	3.10	200	174	87.0
2**	7.23	6.66	7.88	200	27	13.5
3**	23.50	22.14	5.79	200	96	48.0
4**	27.69	25.90	6.46	200	96	48.0

Wood 1 : *Pinus densiflora*, 2 : *Paulownia coreana*
 3 : *Fraxinus rhynchophylla*, 4 : *Betula schmidtii*
 * : Soft wood
 ** : Hard wood

· 종묘에서의 흰개미 서식 분포 및 지중 활동 관찰

1.

2000 5 30 m 55
 , 1 3 165 30 cm
 . (*Pinus densiflora*) (3×5×50 cm) ,
 12 ~ 15% . 1
 2001 5 1 3
 (*R. speratus kyushuensis*) 3
 34.5%(55 19) .
 가 . 1 (2001 5)
 가 3 (No. 3, 19, 45) 3
 (foraging) (8, 9).

< 8> Termite activity of 55 monitoring places in the Jongmyo forest

Location	Monitoring		
	1st(May, 2001)	2nd(May, 2002)	3rd(June, 2003)
No. 3	++	++	++
No. 5			+
No. 12			+
No. 13			+
No. 17	++	++	+
No. 19	++	++	++
No. 22	++	-	-
No. 23	++	-	-
No. 26	++	++	+
No. 27		++	+
No. 28	++	++	-
No. 30	++	++	-
No. 32	++	-	-
No. 44	++	++	+
No. 45	++	++	++
No. 46		++	+
No. 47			++
No. 48	++	++	-
No. 53			++

- + : attacked but found no termite
- ++ : attacked and found termite
- : missing termite after attacked

< 9> Number and percentage of termite activity in the Jongmyo forest

Monitoring	Attack		Termite		Missing	
	No.	%	No.	%	No.	%
1st	12	21.8	12	21.8	0	0.0
2nd	14	25.5	11	20.0	3	21.4
3rd	19	34.5	5	9.1	14	73.7

1st : May, 2001, 2nd : May, 2002, 3rd : June, 2003

2.

가
30cm

4 (A, B, C, D)
4 11 (A), 5 (B), 10 (C) 7 (D)
. 2 2000 9 2001 11 11

(, ,) .
, 1 (2000. 9)
3 (9.1%), 2 5 (15.2%), 3 4 9 (27.3%), 5
10 (30.3%), 6 11 (33.3%), 7 11 12 (36.4%)
, 가 .
(2000 11 ~ 2001 3)
, 가 10 (2000 9 , 2000 11 , 2001
4 ~ 2001 11) . 3 (2001 3) 가 4
(2001 4) (-4.1 ~ 5.0 , 1.7 ~ 5.2)
30cm 가 가 (2001
4) . 7 (2001
7) 8 (2001 8) 2
(2001 7 8) .
가 () 가
. 2000 9
2001 11 () -4.1 (2001 1) , 50%
RH(2001 4) , 26.8 (2001 8) , 76% RH(2001 7) .
0.9 (2001 2) , 26.6 (2001 8) .
12.3mm(2001 4) , 698.4mm(2001 7) . (7
8) 가 , (1 2)
가 1.1 ~ 5.8 . 가 (2001
4) 13.6 , 50% RH , 10.7 , 12.3mm .
(2001 11) 7.0 , 58% RH ,
11.6 , 13.0mm . (20001 7 8) 25.9 ~

26.6 , 24.5 ~ 26.5 . 69 ~ 76% RH ,
 252.0 ~ 698.4 mm
 가 10 , 가 ,
 가 25 .
 가 10 10 ,
 가 .

· 맺음말

가 .
 22 가 가
 Rhinotermitidae *Reticulitermes speratus* Kolbe, *Coptotermes formosanus*
 Shiraki Kalotermitidae *Cryptotermes domesticus* Haviland , 가
R. speratus *C. formosanus* ([9]).
 가 1 . *C.*
formosanus 1 4 , *R. speratus* -4 (山野, 1987),
C. domesticus 10 ([10], [11]).
 .
Neotermes bosei Snyder 35 .
 Western drywood termite *Incisitermes minor*(Kalotermitidae)
 (nymphs) , 가
 ([12]). *Nasutitermes dunensis* Chatterjee &
 Thakur 25 , 100% RH , 35 , 17% RH ,
Coptotermes heimi 15 , 96% RH , 35 , 17% RH
 .
 가 ([8]). 가
 . *C. formosanus* 29 ~ 33 , *R.*
flavipes 29 ~ 31.5 .

[13]). (*R. speratus kyushuensis*) 90% RH 15
가 30 가 , 32 35
20 30
. 10 ~ 30 32 35 35%, 0%
32 . 84% RH(30)
가 (nest) 84%
RH .
가 , 30 ,
(84% RH) . *R. speratus* Kolbe
가 40 *R. speratus kyushuensis* 32
, 가
가 . 가 *R.*
speratus (swarming) 4 ~ 5 , *R. speratus kyushuensis*
2000 5 17 (23 , 65% RH) ([14]).
가 0 32
R. speratus kyushuensis ,
가 (,) 가 5
가 .
, ,
4 , 7 8 , 12 3
. 5
, 8 , 12 4
.
R. speratus kyushuensis
가
(7.88%) (13.5%)
.
,
(*R. speratus kyushuensis*)

Morimoto)가

가 , 가 가

가

() 가

가

가 (*R. speratus kyushuensis*) ,

가

(Integrated

Pest Management, IPM) 가

참고 문헌

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Ecological Characteristics of Termite(*Reticulitermes speratus kyushuensis*) for Preservation of Wooden Cultural Heritage

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In this study, after analyzing several local climate characteristics of South Korea, I validated distribution, invasion, foraging, underground activities, attack season as ecological characteristics and also temperature, relative humidity, and tree species as preference characteristics of Korean termites (*Reticulitermes speratus kyushuensis* Morimoto).

Especially, southern part of the Korean peninsula is a suitable area for inhabitation and motion of termites holding same ecological characteristic like *R. speratus kyushuensis*. Busan is a neighboring district at field distribution north limiting temperature of *Coptotermes formosanus* Shiraki and Chuncheon is a passing area through the Korean Peninsula of field distribution north limiting temperature of *Reticulitermes speratus* Kolbe.

The termite attack of wood devices was about 34.5% for 3 years in the forest of Jongmyo. Although the attack rate of termite increased each year, the detection rate decreased and the missing rate was high by degrees. I confirmed a foraging habits which is a part of termite colony was a role of continuous decomposition and another was a role of new food hunt as experimental results.

The foraging termites were found under ground at Jongmyo in Seoul from April to November in the 2001 and the most active period was on July and August. The termite invasion rate of bait station increased in every monitoring. Through the increasing attack rate of bait station during 2nd monitoring (November, 2000) and 3rd monitoring(March, 2001), I confirmed that termites moved into the deep underground in winter, and were working continuously to forage.

R. speratus kyushuensis inhabiting at the Korean Peninsula is a species which has food consumption rate with higher temperature. The termite revealed the greatest amount of food(filter paper) at 30 (90% RH), but showed increasing death rate at over 32 . Also, survival rate of this termite was 97% at 84% RH(30), but killed 100% at 52% RH(30) and 70% RH(30). For wood feeding, this was observed the preference in a pine tree(*Pinus densiflora*) above all others. Survival of termites was high(87%) at a pine tree, but low(13.5%) at a paulownia tree(*Paulownia coreana*).

In this study, I presented the biological characteristic of termite(*R. speratus kyushuensis* Morimoto) and confirmed the deterioration degree of termite on wooden cultural heritage in Korea. Depending on climate and soil temperature, each area in the southern part of the Korea Peninsula, has some different active period and different distribution of *R. speratus kyushensis*. With these results, I expect that this report helps to prepare the integrated pest management(IPM) of the termite on wooden cultural heritage in Korea, and it may help to reduce the economical loss from termite damage in Korea.

Keyword : termite, *Reticulitermes speratus kyushuensis* Morimoto, climate, Jongmyo, monitoring, integrated pest management(IPM)