4. RESULTS

The total number of samples analyzed in this study was 846 samples. Four groups of samples were used for the interpretation of this study; (1) cut pork; (2) transported pork; (3) retail pork; (4) environmental samples of the slaughterhouse. 173 samples of "cut pork", 173 samples of "transported pork", 200 samples of retail pork (10 bones, 29 bellies, 9 ribs, 23 collars, 33 loins, 33 packs of ground pork, 13 shoulder meats, 21 hams, and 29 fillets) and 300 samples from the slaughterhouse environment (Table 8 and 9) were available.

Table 8: Number of samples of pork for salmonellae analysis

Sampling materials	**Number of samples**
Destructive method	
Cut pork	173
Transported pork	173
Retail pork	200
Total	546

Table 9: Number of samples collected from slaughterhouse environment

Swab surfaces	Number of samples			Total
	Before cutting	During cutting	After disinfecting	
Cutting board	20	20	20	60
Plastic curtain	20	20	20	60
Knife	20	20	20	60
Shackle	20	20	20	60
Hands of staff	20	20	20	60
Total	***100***	***100***	***100***	***300***

4.1 Prevalence of *Salmonella* in pork meat

The prevalence of salmonellae on 173 pig carcasses and 200 pieces of pork during the period of the study, January – May 2005 is shown in Figure 9 within 20 farms, and the summary of descriptive statistics in 3 types of pork during 5 months is shown in Table 10 and Figure 11. Two farms of retail samples were 100 % positive and also were 100% positive in "cut pork" and "transported pork". Most of time during the study, *Salmonella* was presented (Figure 9).

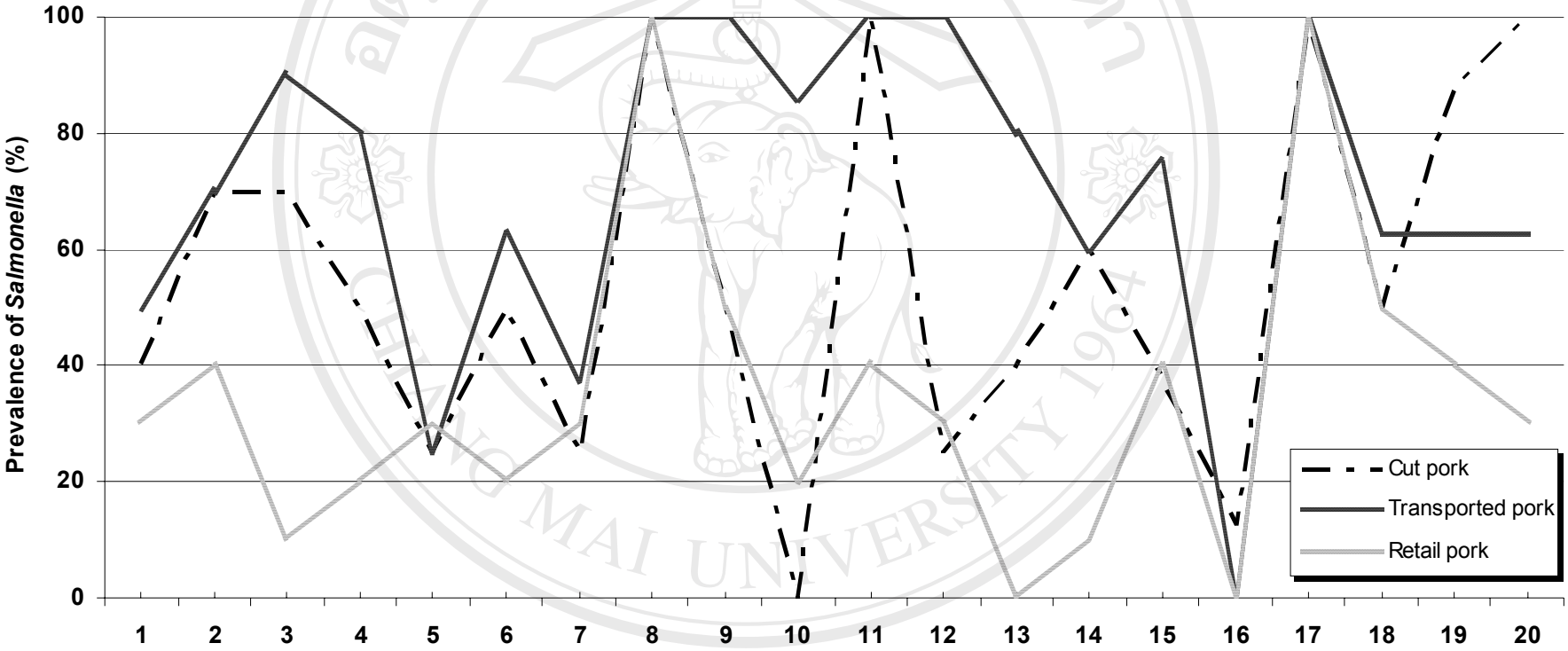

Figure 9: Prevalence of *Salmonella* in 3 types of pork sample in 20 farms

Table 10: Summary of descriptive statistics in 3 types of pork products

Parameter / Type of pork	Count (n)	Mode	Median	Mean	95% Confidence Interval		Standard Deviation (SD)	Standard Error (SE)	Minimum	Maximum	χ^2	*p*-value	df
					Lower limit	Upper limit							
Cut	20	50,100	50	55.49	40.21344	69.03655	30.79297	6.88551	0	100	59.53	0.000005	19
Transported	20	100	72.5	70.52	57.42083	82.89916	27.2196	6.08648	0	100	55.96	0.000017	19
Retail	20	30	30	34.50	22.02706	46.97294	26.65076	5.95929	0	100	59.72	0.000004	19

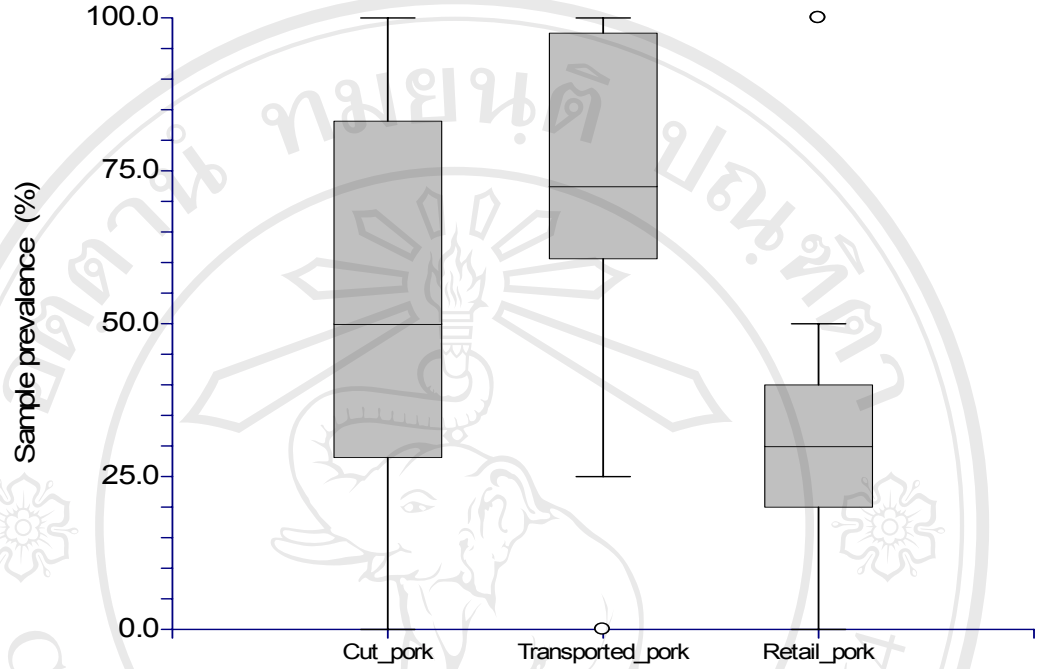

Figure 10: Box-and-whisker plots of sample prevalence of *Salmonella* positivity in three types of pork products

4.1.1 Prevalence of *Salmonella* in "cut pork"

Salmonellae were isolated from a total 55.49% (96/173) of "cut pork" samples (55.49%; 95% CI: 40.21-69.03%) ranging from 0 (1 farm) to 100% (4 farms). The prevalence of "cut pork" at least one farm had significantly different from others (χ^2=59.53; df=19; p=0.000005) (Table 10). Dates of sampling, number of samples examined, number of positive sample and sample prevalence in each farm are shown in Table 11.

Table 11: Prevalence of *Salmonella* in "cut pork"

Farm ID	Date of Sampling	No. of Samples examined	No. of Positive samples	Sample prevalence (%)	95% Confidence Interval	
					Lower limit	Upper limit
1	8 Jan 2005	10	4	40.0	13.69	72.63
2	15 Jan 2005	10	7	70.0	35.37	91.91
3	27 Jan 2005	10	7	70.0	35.37	91.91
4	4 Feb 2005	10	5	50.0	20.14	79.86
5	6 Mar 2005	8	2	25.0	4.45	46.42
6	10 Mar 2005	8	4	50.0	17.45	82.55
7	11 Mar 2005	8	2	25.0	4.45	64.42
8	19 Mar 2005	8	8	100.0	59.77	98.84
9	20 Mar 2005	8	4	50.0	17.45	82.55
10	26 Mar 2005	7	0	0.0	1.32	43.91
11	30 Mar 2005	10	10	100.0	65.55	99.08
12	3 Apr 2005	8	2	25.0	4.45	64.42
13	6 Apr 2005	10	4	40.0	13.69	72.63
14	21 Apr 2005	10	6	60.0	27.37	86.31
15	25 Apr 2005	8	3	37.5	10.24	74.11
16	28 Apr 2005	8	1	12.5	0.66	53.32
17	2 May 2005	8	8	100.0	59.77	98.84
18	5 May 2005	8	4	50.0	17.45	82.55
19	7 May 2005	8	7	87.5	46.68	99.34
20	10 May 2005	8	8	100.0	59.77	98.84
	Total	***173***	***96***	***55.49***	***40.21***	***69.04***

4.1.2 Prevalence of *Salmonella* in "transported pork"

Salmonellae were isolated from 122 of 173 "transported pork" samples (70.52%; 95% CI: 57.42-82.89%). The proportions ranged from 0 % (1 farm) to 100%. The prevalence of "transported pork" had at least one prevalence significantly different among others farm prevalences (χ^2=55.96; df=19; p=0.000017) (Table 10). Dates of

sampling, number of samples examined, number of positive sample and sample prevalence in each farm are shown in Table 12.

Table 12: Prevalence of *Salmonella* in "transported pork"

Farm ID	Date of Sampling	No. of Samples examined	No. of Positive samples	Sample prevalence (%)	95% Confidence Interval	
					Lower limit	Upper limit
1	10 Jan 2005	10	5	50.0	20.14	79.86
2	16 Jan 2005	10	7	70.0	35.37	91.91
3	28 Jan 2005	10	9	90.0	54.11	99.48
4	5 Feb 2005	10	8	80.0	44.22	96.46
5	7 Mar 2005	8	2	25.0	4.45	64.42
6	11 Mar 2005	8	5	62.5	25.89	89.76
7	13 Mar 2005	8	3	37.5	10.24	74.11
8	20 Mar 2005	8	8	100.0	59.77	98.84
9	21 Mar 2005	8	8	100.0	59.77	98.84
10	28 Mar 2005	7	6	85.7	42.01	99.25
11	30 Mar 2005	10	10	100.0	65.55	99.08
12	5 Apr 2005	8	8	100.0	59.77	98.84
13	8 Apr 2005	10	8	80.0	44.22	96.46
14	24 Apr 2005	10	6	60.0	27.37	86.31
15	27 Apr 2005	8	6	75.0	35.58	95.55
16	30 Apr 2005	8	0	0.0	1.16	40.23
17	4 May 2005	8	8	100.0	59.77	98.84
18	7 May 2005	8	5	62.5	25.89	89.76
19	10 May 2005	8	5	62.5	25.89	89.76
20	12 May 2005	8	5	62.5	25.89	89.76
	Total	***173***	***122***	***70.52***	***57.42***	***82.89***

4.1.3 Prevalence of *Salmonella* in "cut pork" and "transported pork"

There was a significant (p=0.0346) difference between prevalence of "cut pork" and "transported pork". The prevalence ratio (PR) of "cut pork" and "transported pork" in this study was 1.195 (95% CI: 0.981-1.455). This indicated an association between "cut pork" and "transported pork" (Table 13). But, the prevalence increased from 55.49 % (96/173) in "cut pork" to 70.52 % (122/173) in "transported pork".

Table 13: 2x2 table of association between *Salmonella* at "cut pork" and *Salmonella* at "transported pork" and the prevalence ratio of their association

		Salmonella at "transported pork"		
		Yes	No	*Total*
Salmonella at "cut pork"	Yes	73	23	*96*
	No	49	28	*77*
	Total	*122*	*51*	*173*

		Logarithmic approximation		χ^2 Approximation	
		Lower Limit	Upper Limit	Lower Limit	Upper limit
Prevalence ratio (PR)	1.195	0.976	1.464	0.981	1.455

4.1.4 Prevalence of *Salmonella* in retail pork

In retail products, 69 out of 200 samples were positive for *Salmonella* testing (34.50%; 95% CI: 22.02-46.97%). In two farms 100% positively and the most frequently occurring is 30%. At least one of the prevalences of retail pork also was

significantly different among other farm (χ^2=59.72; df=19; p=0.000004) (Table 10). Dates of sampling, number of samples examined, number of positive samples and sample prevalence in each farm are shown in Table 14.

The results of salmonellae positive in retail products were found in variable percentages. 70% (7/10) of positive sample was found in bone product and the lowest positive sample was 17.4% (4/23) in collar samples as showed in Figure11

Table 14: Prevalence of *Salmonella* in retail pork

Farm ID	Date of Sampling	No. of Samples examined	No. of Positive samples	Sample prevalence (%)	95% Confidence Interval	
					Lower limit	Upper limit
1	10 Jan 2005	10	3	30.0	8.09	64.63
2	16 Jan 2005	10	4	40.0	13.69	72.62
3	28 Jan 2005	10	1	10.0	0.52	45.89
4	5 Feb 2005	10	2	20.0	3.54	55.78
5	7 Mar 2005	10	3	30.0	8.09	64.63
6	11 Mar 2005	10	2	20.0	3.54	55.78
7	13 Mar 2005	10	3	30.0	8.09	64.63
8	20 Mar 2005	10	10	100.0	65.55	99.08
9	21 Mar 2005	10	5	50.0	20.14	79.86
10	28 Mar 2005	10	2	20.0	3.54	55.78
11	30 Mar 2005	10	4	40.0	13.69	72.62
12	5 Apr 2005	10	3	30.0	8.09	64.63
13	8 Apr 2005	10	0	0.0	0.92	34.45
14	24 Apr 2005	10	1	10.0	0.52	45.89
15	27 Apr 2005	10	4	40.0	13.69	72.62
16	30 Apr 2005	10	0	0.0	0.92	34.45
17	4 May 2005	10	10	100.0	65.55	99.08
18	7 May 2005	10	5	50.0	20.14	79.86
19	10 May 2005	10	4	40.0	13.69	72.62
20	12 May 2005	10	3	30.0	8.09	64.63
	Total	***200***	***69***	***34.50***	***22.02***	***46.97***

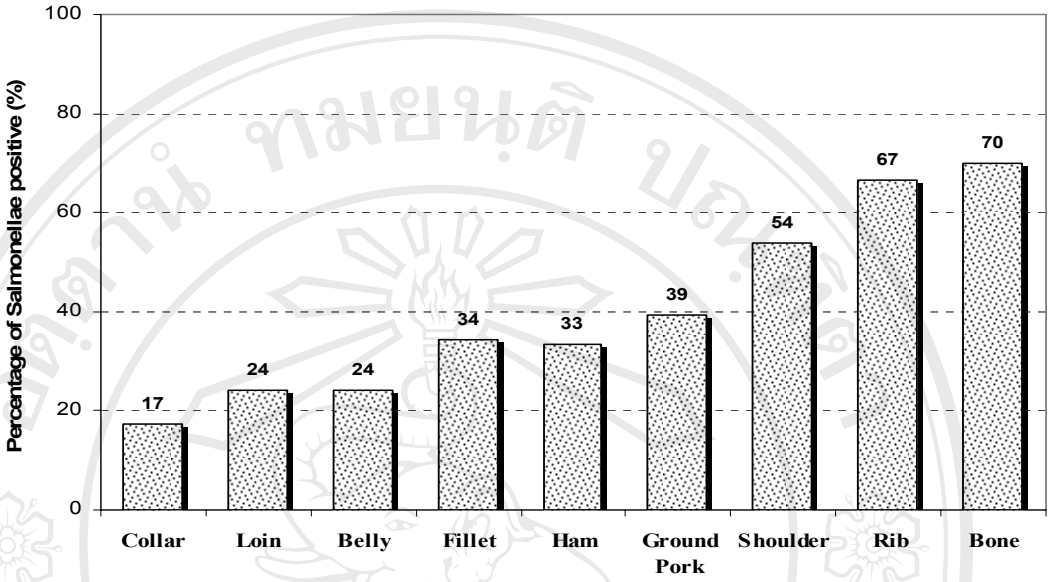

Figure 11: Percent distributions of salmonellae positive retail products

4.2 *Salmonella* in the environment of the slaughterhouse

Salmonellae positive results from the environment are shown in Table 15 and Figure 12. The highest percentage of *Salmonella* positive was found during the cutting period, 25.0% (25/100). *Salmonella* positive results before cutting and after disinfecting were 3.0% (3/100) and 16.0% (16/100), respectively. As can be seen from Table 15, samples from hands, knives and shackles were less frequently positive than samples from cutting boards. No contamination was found on plastic curtains at during any round of sampling occasion.

Table 15: Number and percentage of salmonellae positive samples in environmental samples

Swab technique	Before cutting No. of Positive (%) (95%CI)	During cutting No. of Positive (%) (95%CI)	After disinfecting No. of Positive (%) (95%CI)	Total
Cutting board	0 (0) (0-16.8)	11 (55.0) (31.5-76.9)	12 (60.0) (36.1-80.9)	23(38.3) (26.1-51.8)
Plastic curtain	0 (0) (0-16.8)	0 (0) (0-16.8)	0 (0) (0-16.8)	0 (0) (0-5.9)
Knife	1(5.0) (0.1-24.8)	6 (30.0) (11.8-54.2)	1 (5.0) (0.1-24.8)	8 (13.3) (5.9-24.5)
Shackle	0 (0) (0-16.8)	0 (0) (0-16.8)	1 (5.0) (0.1-24.8)	1 (1.6) (0-8.9)
Hands of staff	2 (10.0) (1.2-31.6)	8 (40.0) (19.1-63.9)	2 (10.0) (1.2-31.6)	12(20.0) (10.7-32.3)
Total	**3(3.0)** **(0.6-8.5)**	**25(25.0)** **(16.8-34.6)**	**16(16.0)** **(9.4-24.6)**	**44(14.7)** **(10.8-19.1)**

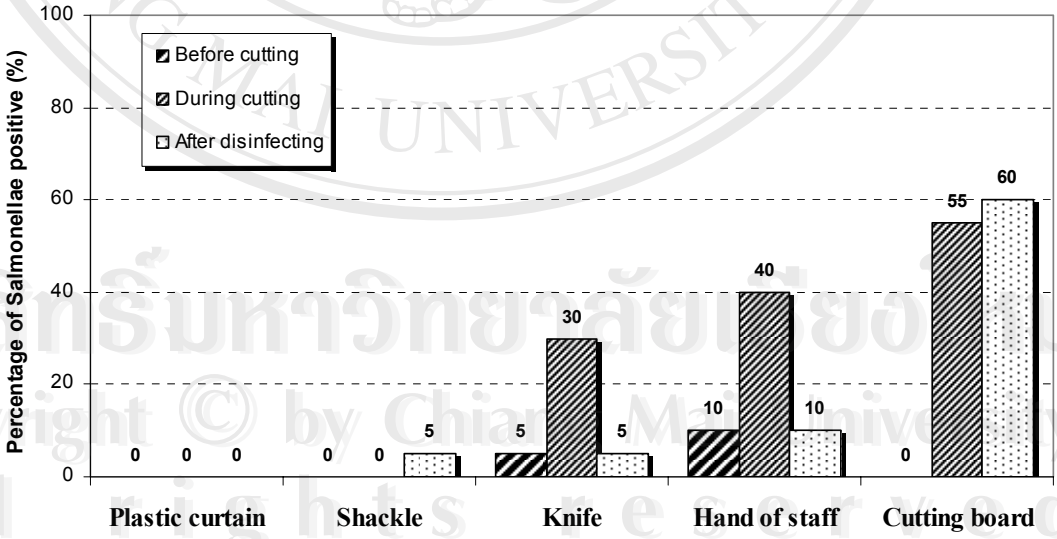

Figure 12: Percentage of salmonellae positive environmental samples at three time intervals in the cutting unit of the slaughterhouse

4.3 *Salmonella* serotypes in meat products and environmental samples

A total of 331 positive samples were identified among 846 samples from cut, transported, retail pork and environmental samples. The three most frequent serogroups were salmonellae belonging to serogroup C (45.0%), B (34.1%) and D (13.9%). In this study, serogroup A was not found (Table 16).

Table 16: Number and percentage of salmonellae serogroup in pork and environment

Type of Sample	SEROGROUP					Total
	B	C	D	E	F-67	(%)
Cutting pork	34 (35.4)	45 (46.8)	4 (4.1)	8 (8.3)	5 (5.2)	96 (29.0)
Transported pork	43 (35.2)	48 (39.3)	3 (2.4)	22 (18.0)	6 (4.9)	122 (36.9)
Retail pork	20 (28.9)	34 (49.2)	2 (2.8)	13 (18.8)	-	69 (20.8)
Environment	16 (36.3)	22 (50.0)	2 (2.8)	3 (6.8)	1 (2.2)	44 (13.3)
Shackles	-	1 (100)	-	-	-	1 (2.2)
Knives	4 (50)	3 (37.5)	1 (12.5)	-	-	8 (18.2)
Hands of staff	6 (50.0)	4 (33.3)	-	2 (16.6)	-	12 (27.3)
Cutting boards	6 (20.0)	14 (60.8)	1 (4.3)	1 (4.3)	1 (4.3)	23 (52.3)
Total (%)	**113 (34.1)**	**149 (45.0)**	**11 (3.3)**	**46 (13.9)**	**12 (3.6)**	**331**

The five most predominant serotypes were *S.* Rissen (45.3 %), *S.* Typhimurium (16.3%), *S.* Krefeld (10.6), *S.* Stanley (6.3%) and *S.* Lagos (6.0%). Also *S.* Panama, *S.* Weltevrenden, *S.* Agama, *S.* Gloucester, *S.* Tumodi, *S.* Anatum were identified (Table 17). *S.* Rissen was the most predominant in every sample type (cut, transported, retail and environmental samples) (Figure 13). The largest variation in serotypes was found in "transported pork" (Table 18). On nine (45%) occasions (farms), there was one serotype of *Salmonella* found in samples from the slaughterhouse and also most of the serotypes also were isolated from pork, e.g. farm ID 2. On other occasions (50%), there was more than one serovar in the environmental samples and also found in pork product samples e.g. farm ID 1. The summary detail of *Salmonella* serotypes isolated from the environment and pork samples are shown in Table 18.

Table 17: The 11 most frequent serovars of *Salmonella* isolated from pork and environmental samples

Serovar	Number of isolates (%)
Rissen	150 (45.3)
Typhimurium	54 (16.3)
Krefeld	35 (10.6)
Stanley	21 (6.3)
Lagos	20 (6.0)
Panama	11 (3.3)
Weltevrenden	8 (2.4)
Agama	7 (2.1)
Gloucester	4 (1.2)
Tumodi	4 (1.2)
Anatum	3 (0.9)
Other	14 (4.2)
Total	**331**

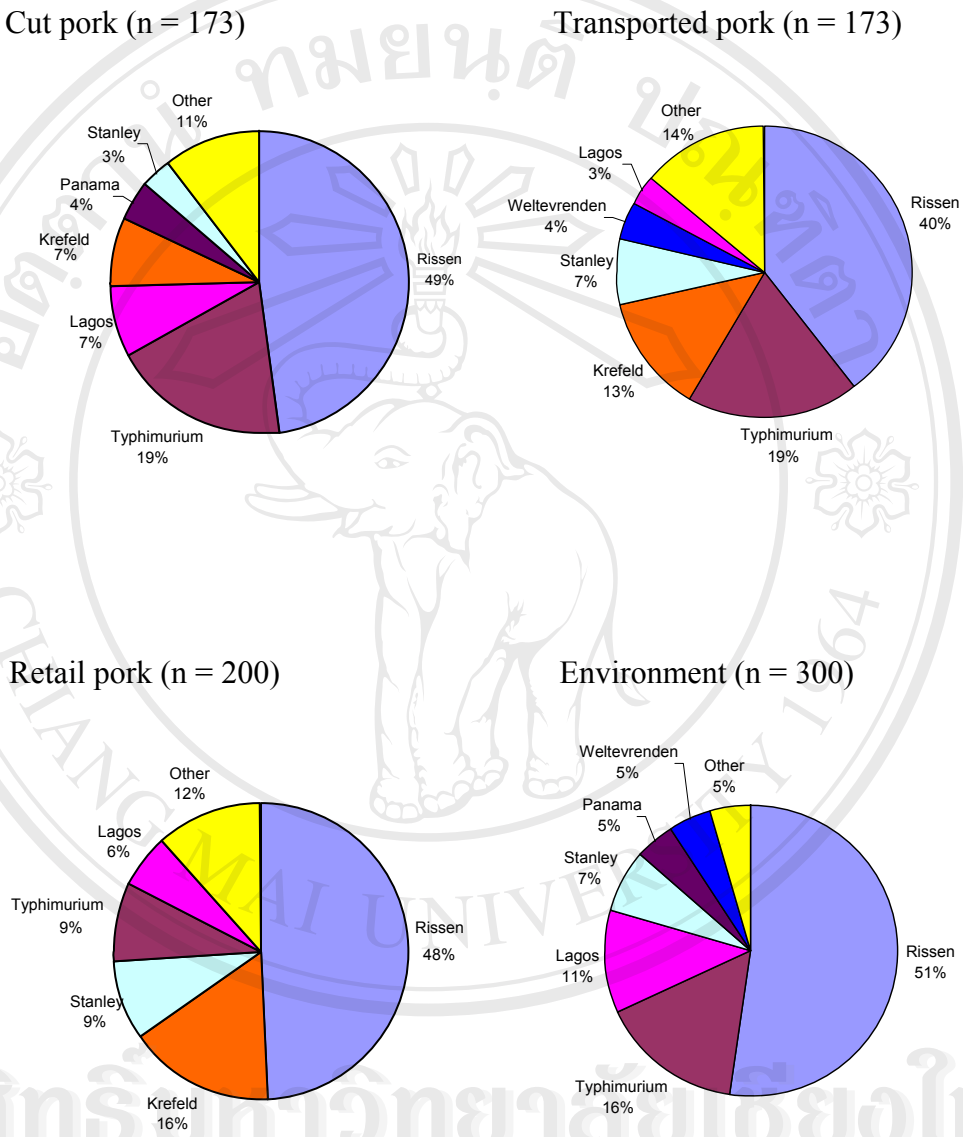

Figure 13: Distribution of the most common *Salmonella* serovars among the different samples

Table 18: Detail of *Salmonella* serotypes isolated from the environment and pork samples

Farm ID	Environment*(Type of sample)			Pork**(Number of sample positives)		
	Before cutting	**During cutting**	**After disinfecting**	**Cut**	**Transported**	**Retail**
1		Panama (B,K)	Rissen (B)	Panama (3)	Rissen (3)	Panama (2)
				Rissen (1)	Panama (2)	Rissen (1)
2		Rissen (B)	Rissen (B)	Rissen (5)	Rissen (5)	Rissen (3)
				Anatum (1)	Krefeld (2)	Anatum (1)
				Krefeld (1)		
3			*F-67*** (B)	*F-67*** (5)	*F-67*** (6)	Lagos (1)
				Rissen (2)	Rissen (3)	
4		Typhimurium (S)	Typhimurium (B)	Rissen (2)	Rissen (2)	Tumodi (1)
		Weltevrenden (B)		Typhimurium (1)	Typhimurium (2)	Krefeld (1)
				Panama (1)	Tumodi (2)	
				Tumodi (1)	Panama (1)	
					Lagos (1)	
5		Rissen (K)		Rissen (1)	Rissen (1)	Rissen (3)
		Lagos (S)		Lagos (1)	Typhimurium (1)	
6		Rissen (B)	Rissen (B)	Rissen (4)	Rissen (5)	Rissen (2)

Table 18 *(Countd.)*

Farm ID	Environment*(Type of sample)			Pork**(Number of sample positives)		
	Before cutting	**During cutting**	**After disinfecting**	**Cut**	**Transported**	**Retail**
7	Rissen (S)			Agama (1)	Rissen (3)	Typhimurium (2) Rissen (1)
8		Rissen (B) Rissen (S)		Krefeld (5) Rissen (2) Lagos (1)	Krefeld (5) Rissen (3)	Krefeld (8) Rissen (2)
9	Lagos (S)	Rissen (B,K)		Rissen (2) Lagos (2)	Krefeld (5) Rissen (1) Lagos (1) Typhimurium (1)	Lagos (3) Krefeld (2)
10		Rissen (K)	Rissen (B)		Rissen (4) Krefeld (1)	Rissen (2)
11		Typhimurium (B,S)		Typhimurium (10)	Typhimurium (10)	Rissen (3) Typhimurium (1)
12		Lagos (B)		Rissen (1)	Rissen (4) Weltevrenden (4)	Rissen (2) Weltevrenden (1)
13	Lagos (K)	Weltevrenden (S)	Krefeld (S) Rissen (B)	Typhimurium (2) Krefeld (1) Rissen (1)	Typhimurium (3) Krefeld (3) Rissen (2)	

Table 18 *(Countd.)*

Farm ID	Environment*(Type of sample)			Pork**(Number of sample positives)		
	Before cutting	**During cutting**	**After disinfecting**	**Cut**	**Transported**	**Retail**
14		Lagos (B)	Typhimurium (K)	Typhimurium (2) Lagos (2) Gloucester (1) Agama (1)	Typhimurium (2) Lagos (1) Gloucester (2) Agama (1)	Agama (1)
15		Typhimurium (S)	Rissen (B)	Typhimurium (2) Lagos (1)	Typhimurium (3) Lagos (1) Agama (1) Gloucester (1)	Agama (2) Stanley (2)
16					Stanley (1)	
17		Rissen (B,S)	Rissen (B)	Rissen (8)	Rissen (8)	Rissen (9) Typhimurium (1)
18			Rissen (B,S)	Rissen (4)	Stanley (3) Rissen (2)	Rissen (5)
19		Stanley (B,S,K)	Rissen (H) Typhimurium (B)	Rissen (6) Stanley (1)	Stanley (5) Rissen (1)	Stanley (1) Rissen (1) Typhimurium (1)

Table 18 *(Countd.)*

Farm ID	Environment*(Type of sample)			Pork**(Number of sample positives)		
	Before cutting	**During cutting**	**After disinfecting**	**Cut**	**Transported**	**Retail**
20			Rissen (B)	Rissen (6) Stanley (1) Typhimurium (1)	Stanley (2) Typhimurium (1) Anatum (1) Weltevrenden (1)	Stanley (2) Typhimurium (1)

* Environmental samples (B = Cutting board; S = Hands of staff; H = Shackle; K = Knife)
**Pork Samples (Number of sample positives)
****Salmonella spp.* in serogroup F-67.