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The surveillance and control programmes for *Salmonella* in live animals, eggs and meat in Norway

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INTRODUCTION

The Norwegian *Salmonella* control programme for live animals, eggs and meat, consists of two separate surveillance programmes, one for live animals (pigs, cattle and poultry), and one for fresh meat (pigs, cattle and sheep) and poultry meat (1). The programmes are approved by the EU Commission (EFTA Surveillance Authority Decision No. 68/95/COL of 19 June 1995), and due to the favourable *Salmonella* situation in Norway (as well as in Sweden and Finland), Norway can require additional guarantees regarding *Salmonella* when importing live animals and feed and food products of animal origin from the European Union.

The programmes were launched in 1995, simultaneously with the programmes in Sweden and Finland (2, 3), and in connection with the Norwegian negotiations for membership in the European Union.

The recorded incidence of human salmonellosis has increased in Norway during the last three decades, with a particularly sharp rise in the early 1980's due to the emergence of *S.* Enteritidis worldwide. In about 80% of human *Salmonella* cases, the patients have acquired the disease abroad. The number of reported cases of salmonellosis corresponds well with charter tourism to foreign countries. Since 1998, the incidence of human salmonellosis has been almost constant, until an increase occurred in 2001; with a total of 1,899 cases reported (4). In Norwegian production animals and animal products, the number of positive samples has constantly remained at a very low level during the last decades.

Both the programme for live animals, and the programme for fresh meat and poultry meat are based on bacteriological examination for *Salmonella*. Isolation of any *Salmonella* sp. must be notified to the authorities responsible for the programmes. The Animal Health Authority maintains overall responsibility for the *Salmonella* surveillance and control programme for live animals, while the Norwegian Food Control Authority is responsible for the *Salmonella* surveillance and control programme for fresh meat and poultry meat. The National Veterinary Institute coordinates both programmes, examines the faecal samples and publishes the results in monthly and annual reports. The Municipal Food Control Authorities perform the examination of samples collected at slaughterhouses and cold stores.

The occurrence of *Salmonella* in Norwegian production animals is very low compared to most other countries. It is very important that this favourable situation is maintained, to reduce the risk to human health by this organism.

OBJECTIVE

The objectives of the programmes are to ensure that Norwegian food animals and food products of animal origin are virtually free from *Salmonella* and to provide reliable documentation of the prevalence of *Salmonella* in the livestock populations and their products. The number of samples examined in the different parts of the programmes is sufficient to detect *Salmonella* if the prevalence in the population is at least 0.1%, with a confidence level of 95%. When *Salmonella* is isolated from live animals, action is taken to eliminate the infection, prevent transmission to other herds, and prevent contamination of food products.

MATERIAL AND METHODS

The *Salmonella* surveillance and control programme for live animals includes faecal samples from swine and poultry, and lymph node samples from cattle and swine, while the *Salmonella* surveillance and control programme for fresh meat and poultry meat includes swab samples from cattle, swine and sheep carcasses, neck skin samples from poultry and samples of crushed meat from slaughterhouses and cold stores.

Structure of Norwegian meat production

A total of 328,00 cattle, 1.3 million pigs, 1.2 million sheep and 40 million poultry were slaughtered in Norway in 2001 (Register of Slaughtered Animals). Fifty slaughterhouses slaughtered cattle, 34 slaughterhouses slaughtered pigs and 44 slaughterhouses slaughtered sheep (slaughterhouses with less than 100 animals per species are not included). Ten different slaughterhouses slaughtered poultry. The frequency distribution of slaughterhouses that slaughter cattle, swine and sheep by the number of animals slaughtered, is given in Figure 1.

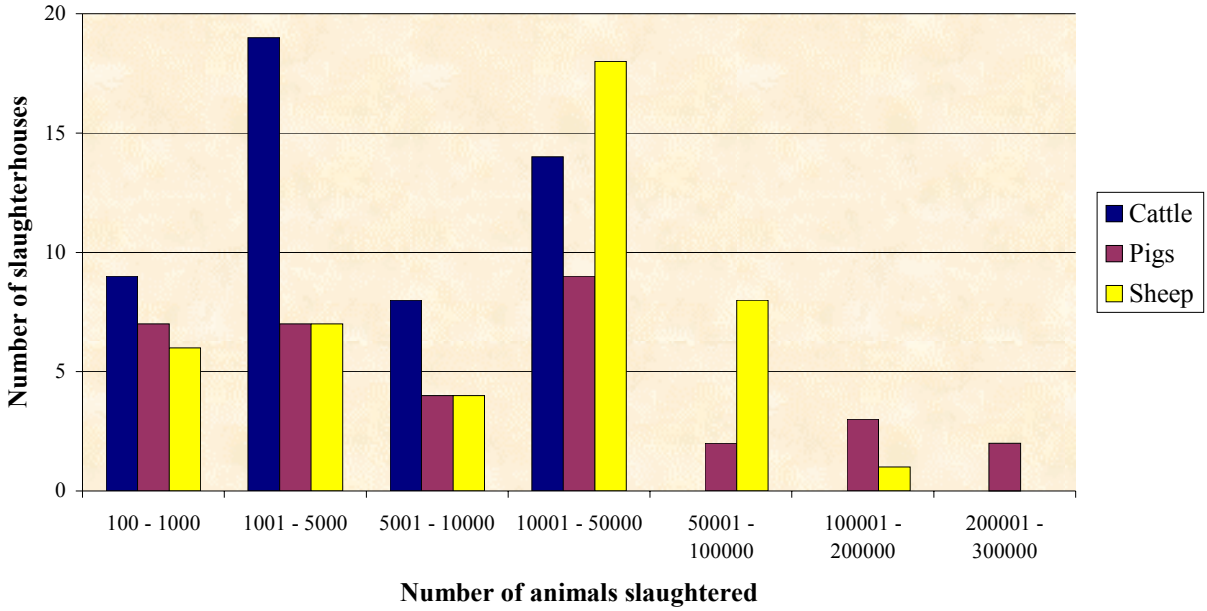

Figure 1. The frequency distribution of slaughterhouses by number of animals slaughtered annually.

Sampling scheme - live animals

Swine

In Norway there are about 180 elite and multiplier breeding herds. More than 95% of breeding animals are purchased from these herds. All elite and multiplier breeding herds are surveyed at herd level once a year. Pooled faecal samples are collected from every pen (up to a maximum of 20) containing piglets aged 2-6 months. If there are no piglets at this age, individual faecal samples (up to a maximum of 59) are taken from all sows (5). Surveillance of the rest of the pig population is based on the sampling of lymph node samples from a representative proportion of all pigs slaughtered in Norway.

Poultry

All breeding flocks and commercial production flocks, except layer flocks with less than 250 birds, are included in the programme. The sampling of certified breeding flocks is performed in accordance with the zoonosis directive (Council Directive 92/117/EEC) (Table 1). All broiler flocks

and flocks of turkeys, ducks and geese other than breeders are sampled 1-3 weeks before slaughter (faecal samples), while layer flocks are sampled twice during the rearing period and one or two times during egg production (1).

Table 1. Sampling of breeders (simplified)

Category of poultry		Time of sampling	Sample material
Grandparents	Day old	Day 1	Organs or meconium
	Rearing	1-2 weeks, 4 weeks, 9-11 weeks and 13-14 weeks	Faecal samples
	Egg production*		
	-from the house	Monthly	Faecal samples
	-in the hatchery	Every 2.week of production	Organs or meconium
Parents	Day old	Day 1	Organs or meconium
	Rearing	4 weeks and 2 weeks before start of production	Faecal samples
	Egg production* -in the hatchery	Every 2.week of production	Organs or meconium

* In hatcheries with a lower capacity than 1,000 eggs at a time, a modified sampling scheme is used, with sampling from the house every two weeks.

Lymph node samples
The surveillance is based on sampling of a representative proportion of all cattle and swine slaughtered in Norway. A total of 3,000 lymph node samples from each of the species are collected at slaughterhouses. The sample size for each slaughterhouse is based on the proportion of cattle and swine slaughtered at this site out of the total number of cattle and swine slaughtered in the country. The sampling is distributed evenly throughout the year and between the days of the week.
An equal number of lymph node samples should be collected from sows and slaughter pigs.

Clinical cases - all species
All animals with clinical symptoms that could be attributed to salmonellosis are tested. In addition, all sanitary slaughtered animals are tested for the presence of *Salmonella*.

Sampling scheme - fresh meat and poultry meat
Swab samples from carcasses
Testing of slaughtered pigs, cattle and sheep for *Salmonella* is done through swabbing of carcass surfaces. About 3,000 swab samples are taken at the slaughterhouses for each of the bovine, porcine and ovine species. The sampling is done before the carcasses are refrigerated, near the end of the slaughter line. The swabbing is performed according to appendix 5 in the *Salmonella* control programme (1). A total area of approximately 1,400 cm^2 per carcass is swabbed (somewhat less for sheep). The sample size for each slaughterhouse is calculated from the proportion of animals slaughtered at the site out of the total number slaughtered in the country as a whole. The sampling is distributed throughout the year and between the days of the week.

Neck skin samples
Pieces of neck skin are used for *Salmonella* testing in broilers, turkeys, ducks and geese. At each slaughterhouse, a minimum of 5 neck skin samples is collected per day. At least one sample must be taken from each slaughtered flock. The samples are marked and pooled according to Appendix 6 in the programme (1). The total number of samples to be taken will be approximately 10,000 which corresponds to a confidence level higher than 95% for the surveillance of the poultry population and a confidence level of 95% at each slaughterhouse.

Food products
The surveillance and control programme in cutting plants and cold stores examines the production hygiene. The samples can be taken from crushed meat, from the equipment or from trimmings. Each sample consists of 25 grams of meat. Each production line is sampled separately. The sampling is done randomly during operation.

Pre-packed fresh meat intended for cold stores does not have to be examined if originating from cutting plants which participate in the programme. Fresh meat which is packed or repacked should be sampled. The number of samples taken in cutting plants and cold stores is given by the production capacity of the plant, and ranges from one sample per day to two per year.

Laboratory methods
Lymph nodes and swab samples are pooled in groups of five before testing. Each neck-skin sample is divided into two equal parts. One part is pooled with other samples and the other half is stored separately at 4°C until the results of the bacteriological examination are ready. The pooled samples of neck skin consist of 4 to 12 individual samples. All other samples are examined separately.

Microbiological investigation of the samples is carried out according to the Nordic Committee on Food Analysis Method No. 71, slightly amended to make the method applicable to the various kinds of materials. This is a qualitative bacteriological method based on selective enrichment and cultivation. All positive samples are confirmed and serotyped by a reference laboratory.

RESULTS

Live animals

Swine
A total of 2,188 faecal samples from 172 elite and multiplier breeding herds were examined in 2001 (Table 2). *Salmonella* was not detected in any of the samples.

Table 2. Sampling in elite and multiplier breeding herds in the *Salmonella* surveillance and control programme in 2001

	Number of pooled samples	Number of individual samples	Number of herds tested	Total number of herds*
Elite breeding herds	831	20	66	68
Multiplying herds	1,305	79	102	110
AI and testing stations	52	59	4	5
Total	2,188	158	172	183

* Total number of herds is based on data from the Norwegian Pig Health Service, January 2001.

Poultry
A total of 6,977 samples from 1,638 different holdings were examined (Table 3). *S.* Agona was detected in one breeding flock which produced parent birds for broiler production. (Table 5, Figure 2). This gives an estimated prevalence of *Salmonella* of 0.06%. (95% confidence interval: 0 - 0.18%).

Table 3. Sampling of poultry holdings in the *Salmonella* surveillance and control programme in 2001

Poultry breeding flocks		Number of samples tested	Number of flocks tested	Number of holdings tested	Number of holdings in Norway *
Grandparents					
Layers		35	5	5	5
Broiler production		16	4	1	1
Parents					
Layers		200	14	7	7
Meat production	- Broilers	1,064	82	75	82
	- Turkeys	133	4	4	4
	- Ducks	11	3	3	4
	- Geese	2	2	2	2
Total - Breeders		1,461	114	95	103
Other commercial poultry					
Pullets		320		27	42 **
Layers		1,388		884	1,139 **
Meat production	- Broilers	3,437	3,437	673	n.a.
	- Turkeys	349	349	82	n.a.
	- Ducks	19	19	5	n.a.
	- Geese	2	2	2	n.a.
Category unknown		1	1	1	
Total - Non breeder holdings		5,516		1,549	n.a.
Total		**6,977**		**1,638**	n.a.

* Total numbers of certified herds are based on data from the Animal Health Authority. Total numbers of breeding flocks are based on data from the Register of Production Subsidies (31 July 2001).

** Including herds with more than 250 animals

n.a. = Not available

Lymph node samples from cattle and swine

In 2001, a total of 2,421 lymph node samples from cattle were examined (Table 4). The animals were from about 1,950 different herds (Figure 3). *S.* Typhimurium was detected in one lymph node sample (Table 4, Figure 2). This gives an estimated prevalence of *Salmonella* of 0.04% at the individual animal level.

A total of 2,480 lymph node samples from swine were examined (Table 4). About 23% of these came from sows while the rest came from slaughter pigs. The animals came from about 1,430 different herds (Figure 4). *Salmonella* was not detected in any of the lymph node samples from swine examined in 2001.

Table 4. Individual lymph node samples from cattle and swine in the *Salmonella* surveillance and control programme in 2001

	Number of Positive samples	Number of samples	Prevalence (individual level)	Confidence interval (95%)
Cattle	1	2,421	0.04 %	0 - 0.12 %
Slaugther pigs	0	1,914	0	
Sows	0	566	0	

Swab samples from cattle, sheep and swine carcasses

A total of 7,681 swab samples from 52 slaughterhouses were examined in 2001 (Table 5). *S. diarizonae* was detected in one swab sample from sheep (Table 5). *Salmonella* was not detected in any of the samples from cattle or swine.

Table 5. Number of swab samples from carcasses examined in the surveillance and control programme for *Salmonella* in 2001

	Swine	Sheep	Cattle	Total
Number of positive samples	0	1	0	1
Number of samples examined	2,452	2,680	2,549	7,681
Number of slaughterhouses involved/number of slaughterhouses that slaughter each of the species.	33/34*	38/46*	45/50*	52/54*

* Slaughterhouses where the number of slaughtered animals of a species is less than 100, according to the Slaughter statistics for 2001, are not included.

Neck skin samples from poultry

A total of 7,135 neck skin samples from poultry were examined in 2001 (Figure 5). *Salmonella* was not detected in any of the samples. The samples came from all 10 different poultry slaughterhouses in Norway. About 77% of the samples came from broilers, 14% from layers and 9% from other species (turkey, duck and geese).

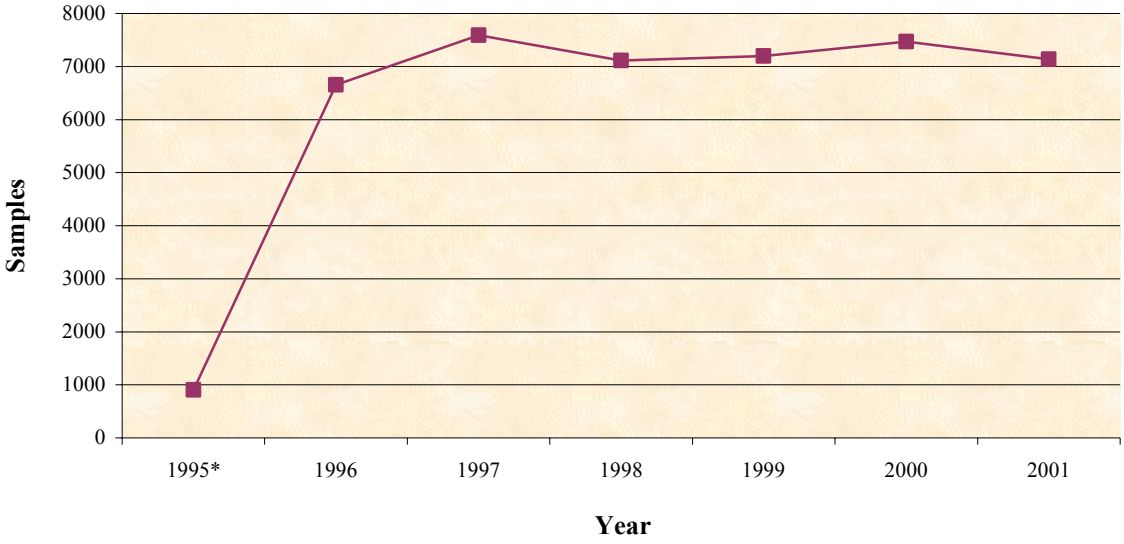

Figure 5. Number of neck skin samples in the period 1995-2001.
* For 1995 the number of samples refers to pooled samples only.

Cutting plants and cold-stores for fresh meat and poultry meat

A total of 2,417 samples of crushed meat from 119 different plants were examined. *Salmonella diarizonae* was detected in one of the samples (Table 6). This gives an observed prevalence of 0.04%, with a 95% confidence interval from 0 - 0.12%.

Table 6. Summary of samples positive for *Salmonella* in the surveillance and control programme for fresh meat and poultry meat 1995-2001

Year	Cattle	Sheep	Swine	Poultry	Crushed meat	Serotype
1995	0	0	0	12	1*	*S.* Livingstone (x 12), *S.* Typhimurium
1996	0	3	0	0	0	*S. diarizonae*/61: k:1,5
1997	0	0	0	0	1	*S.* Dublin
1998	0	2	0	0	0	*S. diarizonae*/61: - :1,5
1999	0	1	0	0	0	*S. diarizonae*/61: k:1,5
2000	0	0	0	0	1	*S. diarizonae*/61: k:1,5
2001	0	1	0	0	1	*S. diarizonae*/61: - :1,5
						S. diarizonae/61 : k:1,5,7

* In 1995 meat samples were examined instead of crushed meat.

Follow-up in herds with samples positive for *Salmonella*
In the dairy cattle herd where *S.* Typhimurium was detected from one lymph node sample, individual samples from all cows and pooled samples from the calves were taken twice. *Salmonella* could not be detected in any of these samples, and the restrictions placed upon the herd were lifted in February 2002.

In the poultry-breeding farm where *S.* Agona was detected, *Salmonella* was confirmed in samples from both flocks (two different houses) at the farm 2 weeks after the first detection. All poultry at the farm were destroyed, and cleaning and disinfection was performed as described in the regulations. Samples taken after these procedures have been negative for *Salmonella*, and the restrictions in the holding were lifted in February 2002. The holding will not be allowed to produce broiler parents until one batch of broilers which has proven to be negative for *Salmonella* based on weekly samples has been produced. Feed samples from the infected farm were negative for *Salmonella*, but at a nearby poultry farm which received a feed shipment the same week, *S.* Agona was detected both from faecal samples and feed samples. These samples were not included in the programme.

DISCUSSION

Based on the results from the *Salmonella* surveillance and control programmes in 2001, we conclude that the estimated prevalence of *Salmonella* infection in the Norwegian cattle, swine, sheep and poultry population is very low. The prevalence was not found to be higher than 0.2% (with a confidence level of 95%) in any of the examined populations. The results are in accordance with results from previous years (Tables 6 and 7) (6, 7). The two programmes partly use different institutions for analysis of the samples, and together they give a substantial amount of data which confirms the very favourable situation concerning occurrence of *Salmonella* in live animals, fresh meat and fresh poultry meat in Norway. Since the programmes started in 1995, no association between detections of *Salmonella* in the surveillance and control programmes and human cases of salmonellosis has been registered. This indicates that Norwegian products of animal origin are not a major source of salmonellosis in humans.

Table 7. Samples positive for *Salmonella* in the *Salmonella* surveillance and control programme for live animals, by species and sample material, in the period 1995-2001

	Cattle	Swine		Poultry		
Year	Lymph nodes	Breeders	Lymph nodes	Breeders	Other	Total
1995	3	1	4	-*	-*	8
1996	3	0	0	0	5*	8
1997	2	0	0	0	0	2
1998	1	0	0	0	2	3
1999	1	0	4	0	2	7
2000	1	1	2	0	2	6
2001	1	0	0	1	0	2

* For poultry, the programme was not completed until 1996. Consequently, data for 1995 are not available. Three of the cases in broilers in 1996 were caused by spread of infection from breeder herds where *Salmonella* was detected in 1995.

The two cases of *Salmonella* detected by the programme in 2001 have been followed up according to the specified regulations (5). In order to reach the objectives of the programme, this follow-up is regarded as crucial.

Although the total amount of poultry meat consumed is increasing, the number of neck skin samples

examined in the programme has almost been constant since 1996. The share of poultry meat purchased fresh (without previous freezing or heat treatment) is also increasing. This suggests that monitoring for *Salmonella* should be increased. Nevertheless, *Salmonella* has not been detected in neck skin samples in the programme since 1995. The detection of *S.* Agona in a breeding flock in 2001 was the first detection of *Salmonella* in breeding flocks since the programme started in 1995. *Salmonella* was not detected in turkeys in 2001, but during the two previous years most of the *Salmonella* detections in poultry were from this species, even though turkey accounts for less than 10% of the annual sale of poultry meat. This is also a situation which warrant continued attention.

For the sampling of poultry other than breeding flocks, an assessment of compliance is complicated by incomplete information about the population. For meat production, the proportion of flocks tested is probably close to 100%, since the slaughter industry requires documentation of negative *Salmonella* control performed less than 2 weeks before slaughter. For the layer population, most producers apply for production subsidies, and according to this register less than 80% of the flocks were sampled properly. Most of the remaining population is still tested for the presence of *Salmonella* because the slaughter industry requires such sampling prior to slaughter; however, these samples are not included in the programme. In 2001, *S.* Agona was detected in one flock of layers through preslaughter testing. This flock was not included in the programme, and this incidence indicates that improved compliance with the programme is needed.

In 2001, 94% of the swine elite and multiplier breeding herds were sampled as part of the programme. For poultry, 92% of the breeding farms were sampled. The breeding populations are not constant, so some of the holdings which were not sampled had closed down, or changed production category, during the year. The real percentage of breeding herds that was sampled was therefore slightly higher.

Only 81 and 83% of the 3,000 lymph node samples that should have been examined from cattle and swine were actually taken. For the swab samples the situation was almost the same, with 85, 82 and 89% of the 3,000 samples which should have been examined for cattle, swine and sheep, respectively. There has been a decrease in the number of both lymph node samples and swab samples included in the surveillance and control programmes during the past years (Figure 6). This could be due to changes in the structure of the slaughter industry, with a shift to fewer and larger slaughterhouses. A revision of the regulations for sampling in the slaughterhouses appears to be needed. Nevertheless, the total amount of samples taken during these years and the very low numbers of positive samples detected (Tables 6 and 7), gives reliable information about the remarkably favourable *Salmonella* situation in the Norwegian livestock population.
About 23% of the swine lymph node samples were from sows. This is higher than in previous years, but is still below the expected 50%.

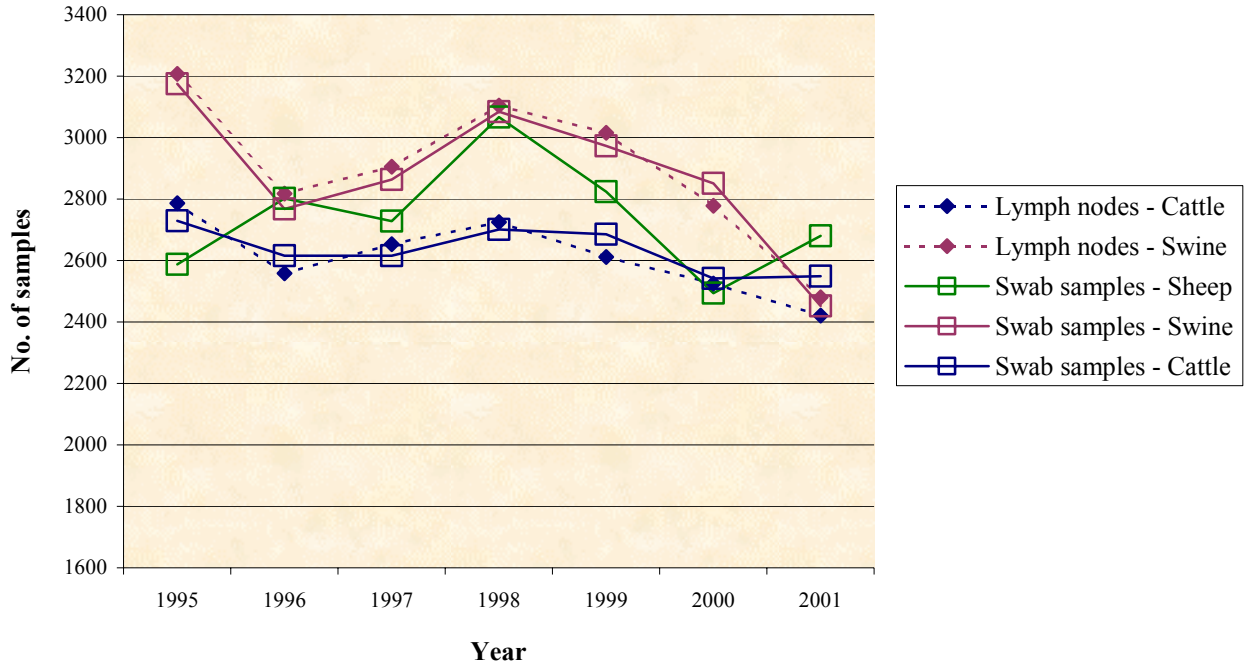

Figure 6. Number of lymph node samples and swab samples taken in the programme in the period 1995-2001.

The *Salmonella* serovar most often detected in swab samples, and occasionally also from samples of crushed meat, is *S. diarizonae* (Table 6). This bacterium is also isolated from healthy sheep in Norway. The pathogenicity of this bacterium for humans is believed to be very low, however, when carcasses are found positive for *S. diarizonae,* they are not used for human consumption.

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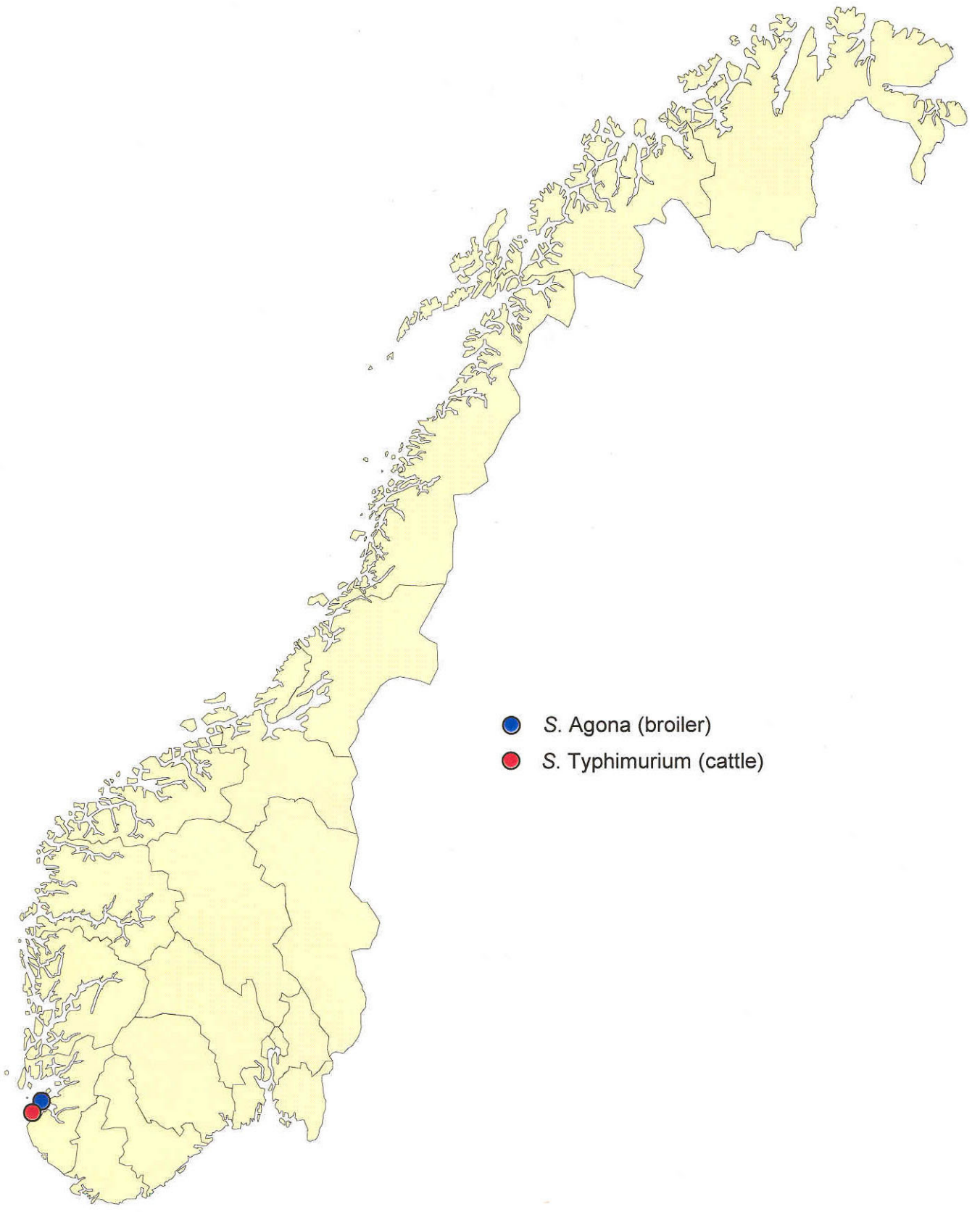

Figure 2. Geographical location of the herds which tested positive for *Salmonella* in 2001.

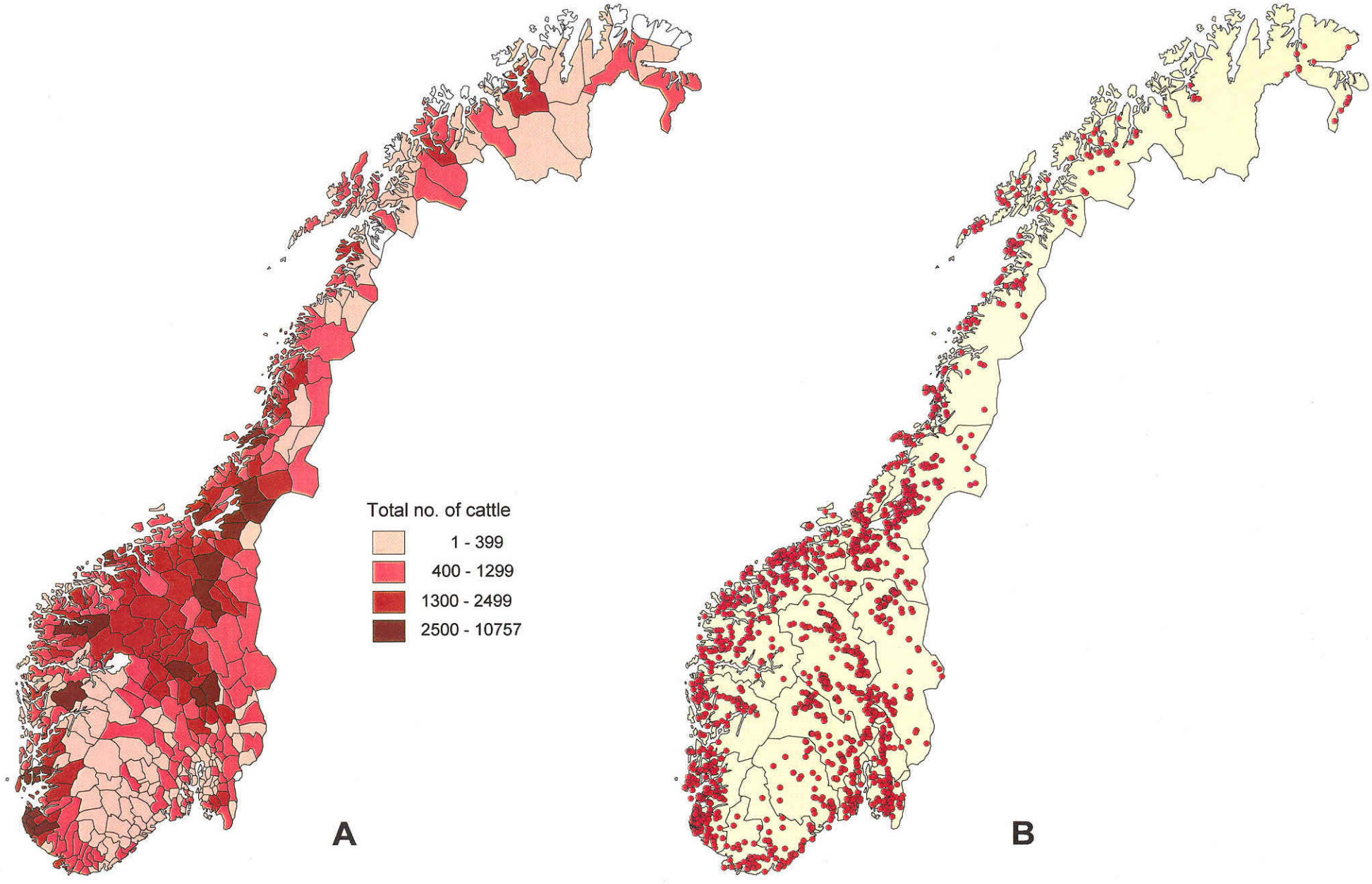

Figure 3. Geographical distribution of the cattle population (no. of cattle > 2 years) on municipality level (A) and the location of the cattle herds which are tested in the surveillance and control programme for *Salmonella* in live animals 2001.

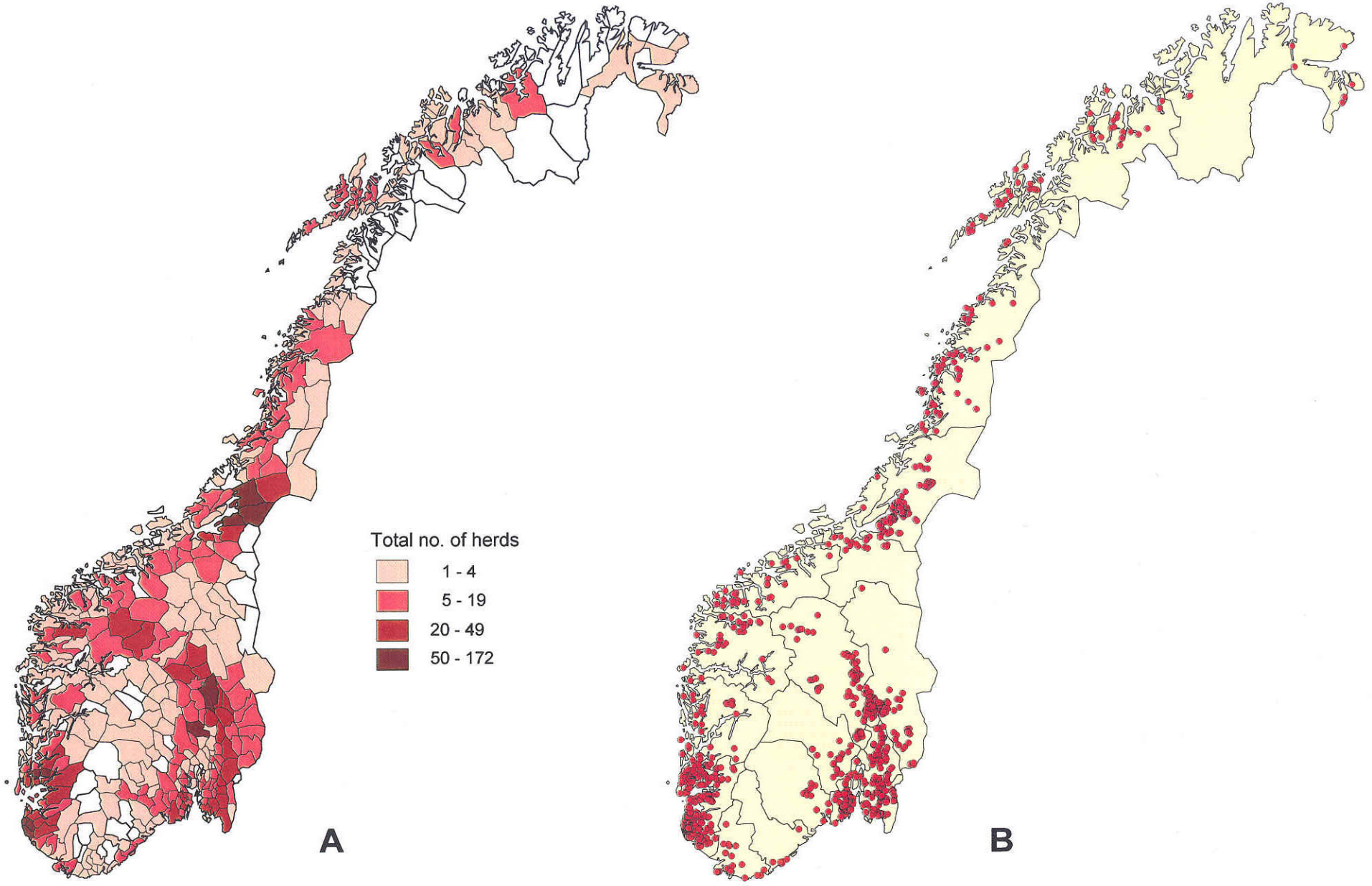

Figure 4. Geographical distribution of the swine herd population on municipality level (A) and the location of the swine herds which are tested in the surveillance and control programme for *Salmonella* in live animals 2001.