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The Year 2009 Worldwide Statistics of Embryo Transfer in Domestic Farm Animals Summary of the International Embryo Transfer (IETS) Data Retrieval Committee Report

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ABSTRACT

***Background*:** For the nineteenth consecutive year, the International Embryo Transfer Society (IETS) Data Retrieval Committee has global embryo transfer (ET) statistics to report. The goal of the IETS Data Retrieval Committee is to collect complete *in vivo* and *in vitro* embryo collection and transfer statistics from every ET practitioner in the world. Although, not all the ET activity that is performed world-wide is included in this report, it is the best report available and gives us a good indication about the trends and directions of the activity different parts of the world.

***Review*:** The number of bovine *in vivo* derived (IVD) embryos collected/flushed worldwide in 2009 was 704,000 compared to 746,000 embryos in 2008. That's a 5.6% decline. However, the number of embryos transferred is down by only 0.5% (from 539,000 to 536,000). North America reported the largest downward slide. A depressed US economy coupled with the discovery of some lethal recessive genes in a popular breed of beef cattle are some of the main reasons for the drop in volume of ET activity there. The number of frozen IVD embryos transferred outnumbered fresh transfers by almost 50,000 (292,000 frozen and 244,000 fresh). The total number of transferrable bovine *in vitro* produced (IVP) embryos worldwide was 379,000 in 2009 compared to 331,000 in 2008. This represents a 12.7% increase in production. Brazil again leads the global field of *in vitro* embryo production and transfers. The total number of IVP embryos transferred worldwide was 307,845. The efficiency of frozen IVP embryos will likely determine the acceptance of *in vitro* technology by other countries. So far, the majority of the IVP embryos transferred have been fresh, not frozen (i.e. only 7% of the IVP embryos transferred in 2009 were frozen). However, that data varies according to different regions of the world. For example, Asia and Europe both reported that 58% of the IVP embryos transferred in those continents were frozen. That's very similar to the percent of *in vivo* embryos transferred that are frozen in those same regions. Consequently, North America (primarily the US) and South America (primarily Brazil) both reported that only 4% of the *in vitro* produced embryos that had been transferred were frozen. Including in vivo and in vitro fresh and frozen, there were 49,465 more bovine embryos transferred in 2009 (843,862) as compared to 2008 (794,397). This represents a healthy 5.9% increase. Many data collectors could not separate beef and dairy embryo production so no attempt was made to estimate that ratio on a global basis. If all species are considered including *in vivo* and *in vitro* production, there were 1,139,981 viable embryos collected / produced and 872,120 embryos transferred into recipients. Equine ET activity was down slightly in 2009. The number of reported flushes (36,971) was down by 7300 compared to 44,338 in 2008. However, the number of transfers (24,491) was only down by about 2500. Small Ruminant ET activity was up by about 40% over the previous year (36,199 transferable embryos were collected in 2009). Australia was the clear leader in ovine embryo production and transfers. Swine ET activity is very low worldwide.

***Conclusion*:** The volume of ET activity reported from all the committee's regional data collectors indicates that the embryo transfer industry is doing well. Is also important to note that this report does not include every country's statistics, and very few, if any, country has 100% of its activity represented; however, it is the best world-wide report available about the commercial embryo transfer business.

Keywords: IETS, statistics, embryo transfer, *in vivo*, *in vitro*.

Descritores: IETS, estatísticas, transferência de embriões *in vivo*, *in vitro*.

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I. INTRODUCTION

For the nineteenth consecutive year, the International Embryo Transfer Society (IETS) Data Retrieval Committee has global embryo transfer (ET) statistics to report [1]. The goal of the IETS Data Retrieval Committee is to collect complete *in vivo* and *in vitro* embryo collection and transfer statistics from every ET practitioner in the world. Although it is very difficult to collect the data from so many different regions in the world, previous chairperson of the committee, Dr. Michel Thibier of France, did a superb job creating data templates and selecting regional collectors who were willing to sacrifice their personal time calling on practitioners in their geographical areas to submit their previous year's information. Countries that are members of regional ET societies or associations i.e., the American Embryo Transfer Association (AETA), the European Embryo Transfer Association (AETE), the Canadian Embryo Transfer Association (CETA), the Brazilian Embryo Technology Society (SBTE) to name a few, are well organized and have established collection protocols that make reporting consistent from year-to-year. Additionally, many countries do not have associations and data collectors in those countries must call on the ET practitioners that they know personally to provide them with data. Certainly, not all the ET activity that is performed worldwide is included in this report. However, it is the best report available of the activity world-wide and efforts are on-going to improve the system.

II. REPORT OF BOVINE IN VIVO DERIVED EMBRYOS IN 2009

For the third consecutive year the reported number of flushes and the number of IVD embryos transferred into recipients has declined (Table 1). Although Asia, Europe and Oceania have reported healthy increases in the number of flushes (18%, 13%, and 400% respectively), North America, South America, and Africa, all reported decreases. Overall, there was a 7% reduction in the number of flushes reported worldwide from 111,806 in 2008 to 104,282 in 2009. The most noteworthy decline in the number of flushes came from North America where there was a reduction of 16,277 from 2008 to 2009.

The biggest decline in that region came from the US where there was a reduction of 15,147 flushes reported, which represents a 29% drop in one year. Mexico, under the direction of regional collector S Romo, has collected data from 14 ET teams which is the most from this country in the short history of this committee. Collectively, they reported 1875 flushes and 10,270 transferrable embryos collected. The ratio of beef to dairy donors flushed was about 4:1 in favor of beef. Close to 9000 bovine embryos were reported transferred in Mexico in 2009. That number however includes both IVD and IVP embryos. Even with a sharp decline in the volume of IVD embryos transferred in 2009 North America still accounts for 46% of the reported in vivo derived embryo transfers worldwide. In the US, for at least a decade the ratio of beef to dairy collections has been 2:1. In 2009 that changed to 1.5:1. There was a drop of 7,000 dairy flushes in 2009 and a drop of 9,000 beef flushes in the US. Canada reported a high preponderance of dairy to beef flushes (4.8:1 ratio) in 2009. The ratio in 2000 was about 3:1, so dairy is playing a more significant role in Canada in recent years.

Africa's flush numbers were down from 2389 in 2008 to 1446 in 2009. However, there was an increase in the number of frozen embryos transferred in 2009, which overall brought them back equal to last year's overall number of transfers. The majority of Africa's ET data is generated from the Republic of South Africa.

Asian data generated in 2009 came exclusively from Japan. One hundred percent of the flushes and fresh transfers that were reported by Asia were done in Japan. Based on reported data Asia is responsible for transferring about 15% of the world's *in vivo* derived embryos. Japan showed an increase in flushes, fresh transfers, and frozen transfers. A serious effort to recruit data collectors from Asia is necessary. No doubt ET is being performed in at least some of the 44 countries in that continent that are currently not reporting. As of now there are only five countries with designated data

collectors; Dochi from Japan, Nguyen from Vietnam, R Parnpai from Thailand, and Seok, Lee, and Son from S Korea, plus SN Lee from Taiwan. However, as previously mentioned, Dochi from Japan is the only one reporting data for the 2009 calendar year. There are reports from Parnpai that Thailand is trying to organize an ET society which will help them gather data from member practitioners in the future.

Europe, a continent of 47 countries, has 25 countries with data collectors for AETE. As always, they are very thorough and prompt with their data reporting. The number of flushes is up from 2008 by 13% (from 14,894 to 16,856). Annually, Europe is responsible for transferring about 18% of the world's IVD embryos.

Globally, more frozen *in vivo* derived embryos were transferred in 2009 than fresh embryos (291,000 and 244,000 respectively). That statistic held true for every continent except South America where four times as many fresh embryos were transferred than frozen. One of the reasons is due to the large number of available recipients in Brazil and Argentina. Also, many more *in vitro* produced embryos (Table 2) are transferred in Brazil where fresh transfers are preferred to frozen.

Brazil reported a significant drop of 25,000 in the number of *in vivo* derived embryos transferred in 2009. However, the difference was made up with 256,000 *in vitro* produced embryos being transferred, which was an increase of 34,000 from 2008. Uruguay now has two regional data collectors, S Kmaid and P Bañalas, who reported 779 flushes of which 21% was dairy and 79% beef. Argentina reported close to 450 dairy collections along with 3400 beef flushes. They also reported 14,385 fresh and frozen transfers combined.

Oceania, especially Australia, has a history of reporting only a small percentage of the ET that is actually done there. Although Australia has a

Table 1. Bovine *In Vivo* Derived Embryo Activity in 2009.

CONTINENT	Flushes	Transferrable Embryos	Number of Transferred Embryos			
			Fresh	Frozen	Total	%
Asia	10,924	112,783	22,958	53,172	76,130	14.23%
Europe	16,856	106,495	43,999	51,074	95,073	17.77%
N. America	52,921	347,531	111,106	137,599	248,705	46.47%
S. America	12,065	67,093	42,876	17,220	60,096	11.23%
Oceania	10,070	60,200	18,522	27,573	46,095	8.54%
Total	104,282	704,230	243,885	291,279	535,164	
2008 Totals	111,806	746,250	242,006	297,677	539,683	
Per Cent Decline	-6.73%	-5.63%	0.78%	-2.15%	-0.84%	

Table 2. The Top Five Countries Outside Europe and North America in 2009 (based on number of bovine *in vivo* embryos transferred).

Country	Number of Flushes	Number Bovine Embryos Transferred
Japan	10,924	75,706
Australia	10,020	46,095
Brazil	NA	42,383
Argentina	3846	14,385
S Africa	1,421	8,753

veterinary society, the Australian Reproduction Veterinarians (ARV)) that encompasses the science of ET, a veterinarian must first be a member of the Australian Veterinary Association (AVA) before joining the ARV. There is also a contingency of non-veterinary ET practitioners that are not members of the veterinary association and are not organized. It's been very difficult for the regional collector, R Pashen, to communicate with both groups. As a result of the confusion the bovine data from Australia is not complete. There was no separation between dairy and beef ET activity reported in Australia. According to the regional data collector (L Frers) New Zealand does not flush many donors (35 dairy and 15 beef) in 2009, but leaned more towards *in vitro* embryo production using sex sorted semen.

III. REPORT OF BOVINE IN VITRO PRODUCED EMBRYOS IN 2009

Globally, the number of *in vitro* produced (IVP) embryos was up by 47,000 (12%) from a year ago (Table 3). Brazil was responsible for 68% of the IVP production, while Japan produced 20% of the world's IVP embryos (Table 3). The number of *in vitro* produced embryos transferred also showed a healthy 17% increase from 254,000 in 2008 to 307,000 in 2009. One of the factors that could be attributing to a decrease in the *in vivo* activity of cattle worldwide is the increase of *in vitro* embryo production, especially in South America. Again, the one valuable resource that Brazil has that some countries don't is a large number of recipients. With a national herd estimated at almost 200 million head, Brazil alone is amply supplied with potential recipients.

If one compares the number of IVD to the number of IVP produced embryos transferred annually over the past decade (see Figure 1) the lines are beginning to converge meaning that the number of *in vivo* and *in vitro* embryos transferred could be on a collision course for similarity. However, Figure 2 illustrates that much of the *in vitro* production is coming from South America, mainly Brazil. Asia comes in second place, but their numbers of transferred IVP embryos are declining in recent years. China did not report any data in 2009 after having reported over 50,000 *in vitro* produced embryos transferred in 2005. Currently there is no regional data collector for the country of China, so Figure 2 could be misleading as to the rise and fall of the transfer of *in vitro* produced embryos from Asia. The rest of Figure 2 clearly shows that other continents are stable with the activity of IVP embryos, and the number of transfers is much lower in those regions of the world.

It will be interesting to see in the coming years if this shift in technology will continue to trend in countries other than those in South America and Asia towards the favor of *in vitro* embryo production.

The efficiency of frozen IVP embryos will likely determine the acceptance of *in vitro* technology by other countries. So far, the majority of the IVP embryos transferred have been fresh, not frozen. Data from Table 3 indicates that overall only 7% of the IVP embryos transferred in 2009 was frozen. However, that data varies according to different regions

Table 3. Bovine *In Vitro* Produced Embryos in 2009.

Continent	Transferrable Embryos	Number of Transferred Embryos			
		Fresh	Frozen	Total	%
Afria	400	100	0	100	0.03%
Asia (Japan)	80775	5923	7764	13687	4.46%
Europe (8 countries)	7653	2389	3419	5808	1.89%
N. America	20390	17850	807	18657	6.07%
S. America	257701	247518	10093	257611	83.85%
Oceania	11325	10666	683	11349	3.69%
Total	378244	284446	22766	307212	

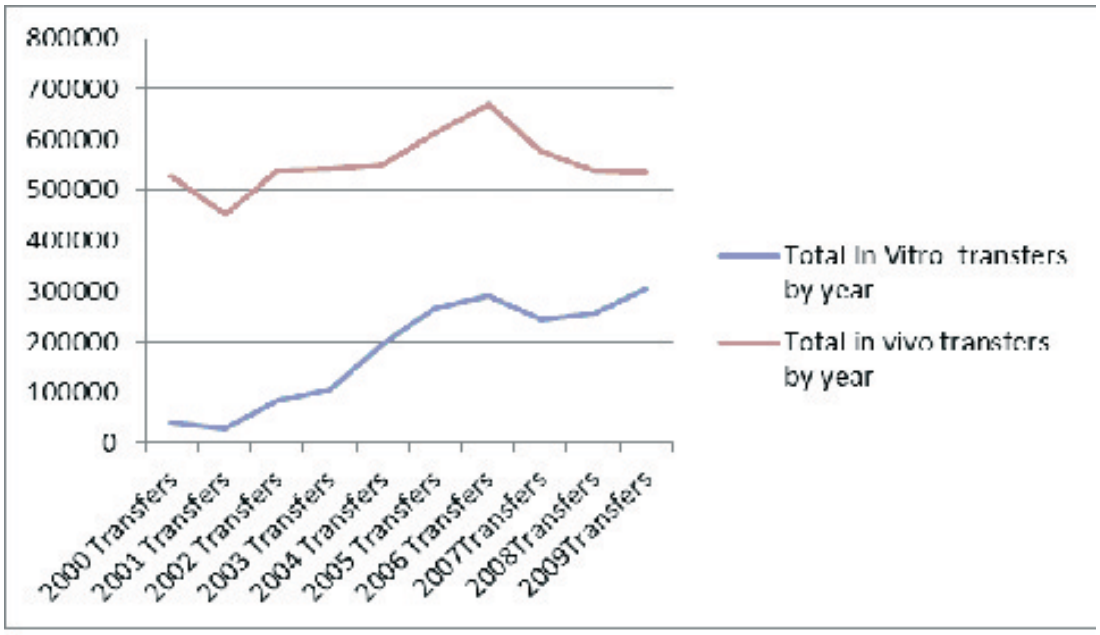

Figure 1. Comparison of the number of *in vivo* and *in vitro* embryos transferred annually for the past decade.

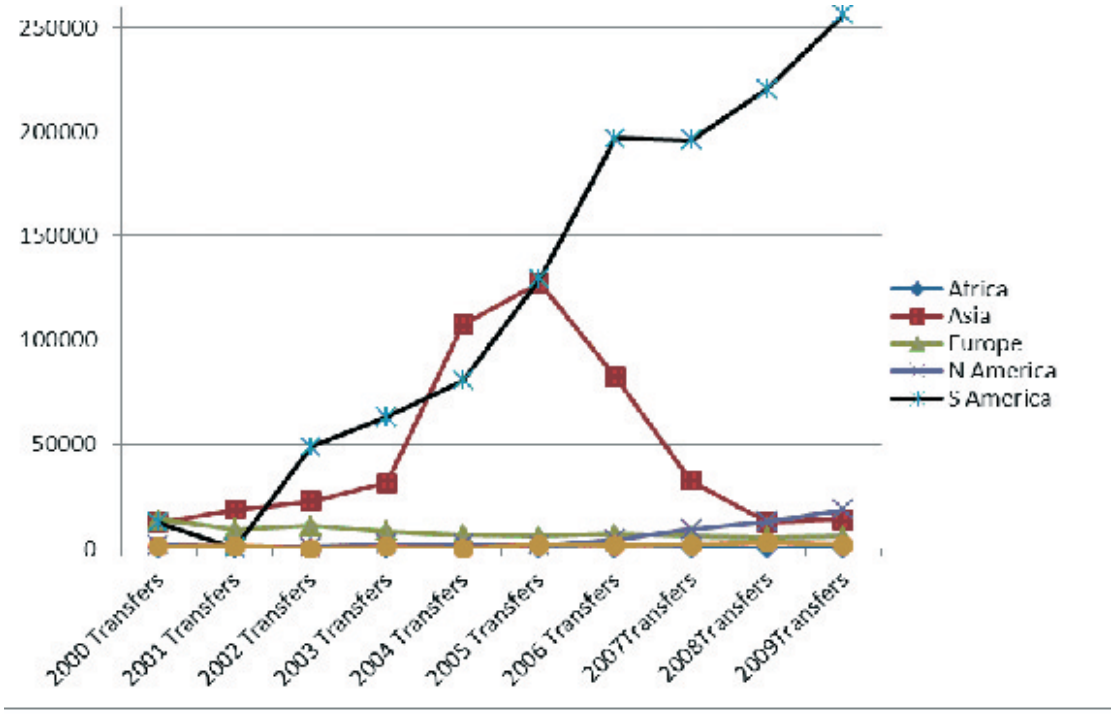

Figure 2. The trends of *in vitro* produced embryos transferred by continents since 2000.

of the world. For example, Asia and Europe both reported that 58% of the IVP embryos transferred in those continents were frozen. That's very similar to the percent of *in vivo* embryos transferred that are frozen in those same regions. Consequently, North America (primarily the US) and South America (primarily Brazil) both reported that only 4% of the *in vitro* produced embryos that had been transferred were frozen.

In Europe eight of the twenty-five countries reporting ET statistics either produced or transferred *in vitro* produced embryos. Germany led with 3271

in vitro embryos produced, whereas Italy transferred the most IVP embryos - 2006. The Netherlands were second in both embryos produced and transferred (2377 and 1930 respectively).

Japan's *in vitro* production came mainly from abattoir derived oocytes, but hey reported 1225 OPU sessions which produced 12,919 oocytes and 2256 transferrable embryos (17.5% efficiency). Additionally, they produced 78,519 viable embryos from 674,584 abattoir oocytes (11.6% efficiency). South Korea, who has reported *in vitro* production in past years, failed to report any ET data in 2009.

Of the five countries reporting from Africa only Kenya reported *in vitro* activity. They produced 400 IVP embryos of which one hundred were transferred fresh and the others were frozen.

Canada, USA, and Mexico, for the first time, all reported in vitro produced embryos from North America. Canada produced 564 dairy and 20 beef IVP embryos. All of the US *in vitro* produced embryos were a product of OPU. 4885 OPU sessions yielded 80,505 oocytes and 19,806 transferrable embryos for an efficiency rate of almost 25%, which could be misleading if some of the ET teams failed to report their oocytes and only reported transferrable embryos. Two ET groups in Mexico reported a combined 238 OPU procedures resulting in 617 transferrable embryos. Including transfer data from a third practitioner, Mexican teams reported 504 fresh IVP embryo transfers of which 86 were frozen abattoir derived IVP embryos.

As previously stated Brazil is the major IVP player in South America, but it should be noted that Uruguay reported 350 OPU sessions producing 1398 embryos. Uruguay also produced 270 abattoir derived IVP embryos. In total, Uruguay reported transferring 1613 *In Vitro* Produced embryos.

Oceania produced a fair number of *in vitro* produced embryos. New Zealand reported 896 OPU sessions and 1725 transferrable embryos. Australia did not report the number of OPUs, but did produce 9600 transferrable *in vitro* produced embryos. The reported total number of bovine *In Vivo* Derived and *In Vitro* Produced embryos transferred in 2009 worldwide was 843,862 which is an increase of 49,462 transfers from the 2008 total of 794,397.

IV. THE OVERALL ACTIVITY OF ET IN OTHER SPECIES IN 2009

In this report, statistics are recorded for three species of small ruminants; sheep, goats, and deer (Table 4). The reported number of viable sheep embryos flushed in 2009 was 13,000 more than in 2008 (32,768 and 18,828 respectively). That's close to a 40% increase. The number of transfers in sheep was probably up too, but Australia did not report how many of their world leading 25,000 embryos collected were transferred. South Africa followed Australia in sheep embryo production. They flushed 925 sheep and collected 5426 viable embryos, but only transferred 35 fresh. Mexico was third with 170 flushes and 1056 transfers. In Europe, Turkey and the Czech Republic combined to collect 197 viable embryos, and transferred 143. R Mapletoft of Canada reported 137 flushes and 565 transferrable embryos recovered in his country. He also reported work done in Chile by a Canadian ET practitioner where 105 frozen embryos were transferred. Mapletoft also reported sheep ET performed in Mexico by a Canadian team. Forty donors were flushed resulting in 241 transferrable embryos of which all were transferred fresh. Mapletoft again reported a Canadian team transferring 104 ovine embryos in the Bahamas.

Table 4. Small ruminant ET activity in 2009.

Species	Transferrable Embryos	Number of Transferred Embryos		
		Fresh	Frozen	Totals
Sheep Total	32768	1326	408	1734
Goat Total	2478	206	146	352
Cervids Total	953	941	0	941
Total	36199	2473	554	3027

*The number of sheep embryos transferred is misleading. Australia reported collecting 25,000 transferrable embryos from 4100 flushes in 2009, but no transfers.

From South America, Uruguay reported 96 flushes and 502 fresh ovine transfers.

Goat collections and transfers were also down significantly in 2009. Only 352 embryos were reported being transferred worldwide compared to an all time high of 20,000 in 2006. Although Australia reported collecting 450 caprine embryos they did not report any transfers. Goat embryo activity in the US is vastly underreported based on verbal communication of the committee chairperson with goat breeders across the country. Only a few bovine ET practitioners in the US are performing caprine ET. The small ruminant ET practitioners seem disinterested in joining the AETA so they don't get ET data surveys sent to them by the association. This is potentially a problem in other countries as well. However, the combined CETA/AETA 2010 annual conference had a small ruminant wet lab that could open the door to this group in the future, at least in North America. Mexico reported 32 goat flushes resulting in 170 transferable embryos all of which were transferred fresh. Mapletoft again gets credit for reporting goat transfers in the United Arab Emirates by a Canadian team. They reported 19 flushes, 173 viable embryos recovered, and 36 fresh transfers.

The volume of cervid ET has remained constant from 2008 to 2009. New Zealand is the only country reporting cervid activity, but the regional collector in New Zealand was not the reporter. Instead, Mapletoft reported that one of his teams from Canada collected 953 *in vivo* produced embryos, and transferred 941 fresh embryos in that country.

The total number of equine flushes was down from 44,000 in 2008 to 37,000 in 2009 (Table 5). Based on the number of transfers the top three countries performing equine ET are Brazil (41% of world's activity), Argentina (31% of activity), and the United States (20% of activity). North America reported the largest drop from 13,500 to 10,000. P McCue, the new regional data collector from the USA did a thorough job of soliciting the equine breed associations in the US for accurate data. The American Quarter Horse Association (AQHA), which is the largest breed association that allows registration of ET foals, reported an all time high of 4069 ET foals in 2007. The last two years showed consecutive declines of ET foals of 3288 and 2458 respectively. Brazil remained stable with 14,100 flushes which was only 100 fewer than 2008. Argentina was down in flushes but stable with transfers. Canada was down from 42 mares flushed in 2008 to 26 in 2009. Collectively, Europe reported 1024 flushes in 2009, which was down from 1216 the previous year. Although the specific country is unclear, S Merton from Europe reported that 60 *in vitro* produced equine embryos were transferred in 2009 (Italy) which is up from 48 in 2008. There was no equine activity reported from Asia in 2009 or 2008. The Republic of South Africa was the only country reporting equine flushes in 2009 from the African continent. They more than doubled their

Table 5. Equine ET Activity in 2009.

Country	Flushes	Transferrable Embryos	Number of Transferred Embryos			
			Fresh	Frozen	Total	%
Argentina	10800	7560	7500		7500	30.65%
Brazil	14100	10100	10100	15	10115	41.34%
Canada	26	22	22	0	22	0.09%
Europe	1024	1037	1037	0	1037	4.24%
South Africa	162	120	120	0	120	0.49%
Australia	910	710	710		710	2.90%
USA	9933	4966	4966	0	4966	20.29%
Total	36955	24515	24455	15	24470	
2008 Totals	44338	27082	26606	379	26985	

2008 count of 56 flushes to 120 in 2009. South America dominated the equine ET world by reporting 72% of all that species activity. Oceania, by way of Australia, reported 910 flushes (up from 24 in 2008) and 710 transfers.

The reported number of swine flushes is down by 80% in 2009 (Table 6). The USA was largely responsible for the sharp decline. In 2008 the US reported 134 flushes, but only 9 flushes for 2009. Those 9 collections were reported by Mapletoft from Canada. It's unclear if swine ET activity is actually down or the data is not being reported. Again, the swine ET industry is not associated with the AETA in the USA, so the regional collector has no connections to anyone performing swine embryo transfers.

Table 6. Swine ET activity in 2009.

Country	Flushes	Transferrable Embryos	Number of Transferred Embryos			
			Fresh	Frozen	Total & Percentage	
Canada	10	325	380		380	48.72%
Czech Republic	NR	716	20	0	20	2.56%
USA*	9	132	0	0	0	0.00%
France**	10	325	380	0	380	48.72%
Total	29	1498	780	0	780	
2008 Totals	149	3800	3092			

*All embryos exported **325 embryos exported.

V. CONCLUSIONS

The volume of ET activity reported from all the committee's regional data collectors indicates that the embryo transfer industry is doing well. As always some country's data is up and others are down. Anyone reading this report should take into consideration that it does not include every country's statistics, and very few, if any, country has 100% of its activity represented. To guess what percent of the world's actual ET is represented in this document would be unprofessional at best, so no attempt will be made to do so; however, it is the best world-wide report available about the commercial embryo transfer business.

Acknowledgments. The chairman would like to thank all the regional and country collectors that spend a considerable portion of their personal time each summer or winter (depending on the hemisphere) calling and emailing their fellow practitioners for all their data. It is a thankless job, but the Statistics and Data Retrieval Committee is perhaps one of the most important the IETS has. For 19 consecutive years the data has been gathered, assimilated, and published for the world to see. For as many man hours that it takes to prepare the report a great deal of gratitude should be given to those involved. Lastly, we would like to thank Dr. Michel Thibier, the former committee chair, for his sincere dedication and time.

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