

2017 Statistics of embryo production and transfer in domestic farm animals

Is it a turning point? In 2017 more *in vitro*-produced than *in vivo*-derived embryos were transferred worldwide

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1. Executive summary

The International Embryo Transfer Society (IETS) Data Retrieval Committee presents the 27th annual report on the data collected globally during 2018 for embryo transfer (ET) activities in 2017. The number of countries submitting data this year was similar to previous years (approximately 20%; Table 1). We recovered a greater amount of data from South American countries, but lesser from Asia and Oceania. The lack of comprehensive ET data from these regions results in an underestimation of total ET numbers, and will require further attention by this committee. Nevertheless, the countries submitting data are representative of the world embryo industry and recovered data allow the characterization of the main trends and perspectives for ET activity.

Table 1. Number and proportion of countries submitting ET data, by region and species

Region	Bovine		Other (IVD + IVP)				% countries within region
	IVD	IVP	Horses	Sheep	Goats	Other*	
Africa	2	3	0	1	0	0	7.4% (04/54)
Asia	1	0	0	0	0	0	2.1% (01/48)
Europe	24	10	9	4	2	1	53.2% (25/47)
North America	3	3	2	2	2	2	100.0% (03/03)
Oceania	1	1	0	0	0	0	7.1% (01/14)
South America	4	8	1	2	1	0	27.8% (10/36)
Total	34	25	12	9	5	3	21.3% (43/202)

* Swine, cervids, buffalo

The numbers of the world embryo industry in 2017 in the four most representative farm species are summarized in Tables 1 (total embryo production/collection) and 2 (numbers of transferred embryos). In cattle, 1,487,343 transferrable embryos were collected or produced in 2017, from which 33.3% (495,054) were *in vivo*-derived (IVD) and 66.7% (992,289) were *in vitro*-produced (IVP) embryos.

Table 2. Total transferrable IVD and IVP embryos in 2017 in cattle, sheep, goats, and horses, according to region.

Region	Cattle		Horses		Sheep		Goats	
	IVD	IVP	IVD	IVP	IVD	IVP	IVD	IVP
Africa	5,126	5,423	0	0	127	0	0	0
Asia	212	0	0	0	0	0	0	0
Europe	143,246	52,879	1,211	1,142	6,435	0	76	0
North America	292,755	475,969	50	0	2,826	66	3,106	61
Oceania	4,485	4,332	0	0	0	0	0	0
South America	49,230	453,686	19,560	180	9,264	0	793	0
Total	495,054	992,289	20,821	1,322	18,652	66	3,975	61

This year, for the first time in the IETS records, both total production and the number of transfers were greater for IVP than for IVD embryos in cattle. Compared to 2016, there was a 48.9% increase in the number of IVP embryos recorded, whereas the number of IVD embryos collected decrease by 21.7%, resulting in a 2-fold difference between IVP and IVD totals (992,289 vs. 495,054; respectively). The main factor driving this change was a remarkable growth of *in vitro* embryo production (IVEP) both in North America (+82.7%) and Europe (+164.7%). The development of IVEP in these regions affected the world ET scenario and, for the first time since 1999, the number of IVP embryos in North America was greater than South America. Nevertheless, a smaller proportion of the total IVP embryos were actually transferred in North America, when compared to South America (56.2% vs. 95.2%, respectively). Consequently, South America still ranks first in the number of transferred IVP embryos. The United States and the Russian Federation accounted for 95.5% and 51.5% of IVP embryos in North America and Europe, respectively.

In spite of these changes within regions, some of the main trends of IVEP were unaffected. For example, transvaginal ultrasound-guided follicle aspiration (a.k.a. ovum pick-up or OPU) remains as the main source of oocytes for IVEP, and only 1.2% of IVP embryos were produced using abattoir-derived oocytes. Similarly, the proportion of transfers performed as fresh was higher for IVP than for IVD embryos (66.1% vs. 39.9%, respectively). Nonetheless, cryopreservation of IVP embryos has been increasing over the past years, pushed by the demand for the international trade of cattle germoplasm. Amongst all bovine embryos exported in 2017, 18.7% were IVP.

In general, embryo production within dairy and beef breeds was slightly more balanced for IVD than for IVP embryos (48.4% vs. 51.6% and 56.4% vs. 43.6%, respectively). However, there were remarkable differences among regions. Dairy breeds accounted for most of the embryos produced or collected in Asia (100%) and Europe (72.8%), whereas embryos from beef breeds were predominant in Africa (90.3%) and Oceania (100%). In North and South America, regions that accounts for 85.5% of the world totals, embryo activity in dairy and beef breeds were quite similar (54.5 vs. 45.5% and 46.9% vs. 53.1%; respectively).

Table 3. Transfers of IVD and IVP embryos in 2017 in cattle, sheep, goats, and horses, according to region.

Region	Cattle		Horses		Sheep		Goats	
	IVD	IVP	IVD	IVP	IVD	IVP	IVD	IVP
Africa	5,748	4,306	0	0	127	0	0	0
Asia	200	0	0	0	0	0	0	0
Europe	131,970	49,752	1,210	428	4,308	0	85	0
North America	217,158	259,895	48	0	501	55	2,711	0
Oceania	4,452	3,900	0	0	0	0	0	0
South America	46,759	432,058	19,210	115	7,635	0	793	0
Total	406,287	757,652	20,468	543	12,571	55	3,589	0

In species other than cattle, the horse was the one with more embryos collected in 2017 (22,143). In sheep, however, ET was recorded in more regions (Africa, Europe, North America, South America). Europe led the use of IVEP in horses and buffalo, while sheep and goats IVP embryos were recorded only in the United States.

In summary, ET data for the year of 2017 highlight important ongoing changes in the world embryo industry, and the most remarkable one is the consistent growth in the use of *in vitro* technologies in all regions with higher ET numbers. The increasing adoption of IVEP worldwide may drive significant changes in ET and associated activities, as occurred in the past within those countries where it became the technique of choice for embryo production.

2. Introduction

The Data Retrieval Committee (DRC) is the committee of the International Embryo Technology Society (IETS) in charge of gathering, organizing, and publishing the statistics of the embryo industry in domestic farm animals. This year we present our 27th annual report showing data on global activities related to *in vivo* and *in vitro* embryo collection and transfer in 2017. The results shown in the present report will be discussed during the Committee meeting, schedule for the next IETS meeting, in New Orleans, Louisiana, USA, and will support further decisions and strategies for the DRC in the following years.

3. Methodology

Data collection followed the standard methodology used in previous reports, as described by Perry (2014). In summary, embryo technology activity was either reported for each country by a national data collector or reported individually by practitioners or representatives of commercial companies (e.g. IVEP laboratories). In several countries, the data collector is linked to the national embryo transfer/technology association: Argentina (Sociedad Argentina de Tecnologías Embrionarias, SATE), Brazil (Sociedade Brasileira de Tecnologia de Embriões, SBTE), Canada (Canadian Embryo Transfer Association, CETA), Mexico (Mexican Embryo Transfer Society, META), Peru (Asociación Peruana de Reproducción Animal, ASPRA), the United States (American Embryo Transfer Association, AETA). For the Member States of the European Union and other European countries, data is submitted by a regional collector on behalf of the Association Européenne de Transfert Embryonnaire (AETE). Data was also reported by ET teams or companies working abroad. In a few countries, this was the only source of information of embryo activity. When there was also similar data reported by a local representative, however, data coming from such teams or companies were not used, to avoid double-reporting. The updated list of regional data collectors and local collaborators is shown in Appendix 1.

Data was directly uploaded to the IETS website by the national collector or sent to the Chair of the DRC. The software managing the database generated MS Excel csv files with data organized by criteria defined in the data submission form. A summary of the results is shown according to region, technology (*in vivo*-derived [IVD] or *in vitro*-produced [IVP]), and species, in Tables 4 to 12. South American numbers include those collected from South and Central America countries. Detailed country information is presented in the Appendix section. Data was also used to build historical series, shown in Figures 2 to 4.

4. Results

Data retrieval

In 2017, ET data were recovered from 43 countries (Figure 1). Despite of representing only 21.3% of all countries in the world, the numbers obtained are probably representative of the embryo industry activity worldwide, as the represented countries account for approximately 46.0% of the world cattle population (FAO, 2016). Over the past years, consistent data has been recovered from the Americas and Europe, and in 2017 we collected data from all North American (3/3) and from most of the South American (8/13) and European (25/47) countries. On the other hand, few Australian and no New Zealand ET teams submitted data and numbers from Oceania are clearly underestimated. Additionally, data recovery from Asia remains a challenge, as we had no feedback from most regional collectors. Moreover, in 2017 we did not receive data from Japan, which has probably the most active embryo industry in Asia, impairing any conclusion about embryo activity in this region.



Figure 1. World political map showing the countries that submitted 2017 ET data

4.1 Embryo industry in numbers

A total of 1,487,343 transferrable embryos were collected or produced in 2017, from which 33.3% (495,054) were IVD and 66.7% (992,289) were IVP embryos. Despite of the higher total number of IVP embryos, more countries reported collection and/or transfer of IVD embryos than of IVP embryos (34 vs. 25, respectively).

The collection of IVD embryos in 2017 is shown in Table 4. There was a decrease in the total IVD transferrable embryos in 2017, compared to 2016 (495,054 vs 632,638; -21.7%), due to a proportional reduction in the number of cows flushed, as the average number of ova and transferrable embryos per flush were similar (10.6 and 6.4 in 2017 vs. 10.0 and 6.7 in 2016, respectively). North America accounts for 59.1% of all IVD embryos collected, mainly because of the United States numbers (224,281; 45.3% of total, Appendix 2).

Table 4. Collection of bovine IVD embryos per region

Region/ Country	Flushes			Collected					
				Ova			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa	32	699	731	539	5,528	6,067	333	4,793	5,126
Asia	60	0	60	382	0	382	212	0	212
Europe	17,592	4,664	22,256	175,060	43,180	218,240	114,095	29,151	143,246
N America	16,722	27,912	44,634	172,712	351,057	523,769	99,984	192,771	292,755
Oceania	0	1,035	1,035	0	6593	6593	0	4485	4485
S America	4,331	4,501	8,832	25,152	40,572	65,724	24,758	24,472	49,230
Total	38,737	38,811	77,548	373,845	446,930	820,775	239,382	255,672	495,054

The transfer of IVD embryos in 2017 is shown in Table 5. A greater number of frozen/thawed embryos were transferred compared to fresh embryos (60.1% vs. 39.9%, respectively). This trend was consistent in all regions, except for Asia – probably due to unrepresentative numbers. Imported embryos accounted for 3.3% of all frozen embryos transferred. In Greece, only imported embryos were transferred.

Table 5. Transfer of bovine IVD embryos by region

Region/ Country	Fresh			Frozen domestic			Frozen imported			Total ET
	Dairy	Beef	Unsorted	Dairy	Beef	Unsorted	Dairy	Beef	Unsorted	
Africa	94	2,220	0	77	1,982	0	116	1,259	0	5,748
Asia	192	0	0	8	0	0	0	0	0	200
Europe	45,478	5,156	720	54,025	21,064	471	4,393	607	56	131,970
N America	36,909	51,068	0	38,901	89,581	0	53	646	0	217,158
Oceania	0	2,113	0	0	1,935	0	0	404	0	4,452
S America	8,444	9,078	458	16,864	11,271	199	76	212	157	46,759
Total	91,117	69,635	1,178	109,875	125,833	670	4,638	3,128	213	406,287

The production of embryos *in vitro* in 2017 is shown in Tables 6 (OPU-collected oocytes) and 7 (abattoir-derived oocytes). The combined total reached almost one million embryos produced (992,289), which is a world record and, most importantly, indicates a remarkable increase when compared to 2016 (+48.9%). Moreover, for the first time since 1999, the number of IVP embryos from North America was greater than South America, a region that led the use of IVEP in the past decade. The United States and Brazil had the greatest numbers within their regions, accounting for 95.5% and 76.2% of IVP embryos in North and South America, respectively (Appendix 4). Ovum pick-up (OPU) was the main source of oocytes for IVEP and only 1.2% of IVP embryos were produced using abattoir-derived oocytes. It is noteworthy that, in previous years, abattoir oocytes were largely used in Asia, and the lack of data from this region may bias the relative importance of this source of oocytes.

Table 6. Production of embryos *in vitro* with OPU-collected oocytes by region

Region/ Country	Donors			Oocytes			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa	827	1,633	2,460	2,099	20,801	22,900	687	4,693	5,380
Asia	0	0	0	0	0	0	0	0	0
Europe	13,997	4,687	18,684	147,148	63,949	211,097	28,152	23,819	51,971
N America	91,303	26,163	117,466	1,444,214	586,858	2,031,072	311,867	156,361	468,228
Oceania	0	833	833	0	18,003	18,003	0	4,332	4,332
S America	42,031	44,452	86,483	763,440	685,213	1,448,653	210,144	240,469	450,613
Total	148,158	77,768	225,926	2,356,901	1,374,824	3,731,725	550,850	429,674	980,524

Table 7. Production of embryos *in vitro* with abattoir-derived oocytes by region

Region/ Country	Donors			Oocytes			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa	0	35	35	0	562	562	0	43	43
Asia	0	0	0	0	0	0	0	0	0
Europe	196	113	309	2,744	1,532	4,276	629	279	908
N America	0	0	0	19,312	2,723	22,035	6,776	965	7,741
Oceania	0	0	0	0	0	0	0	0	0
S America	23	0	23	3,682	5,506	9,188	1,128	1,945	3,073
Total	219	148	367	25,738	10,323	36,061	8,533	3,232	11,765

The number of IVP embryos transferred in 2017 is shown in Table 8. A smaller proportion of the total IVP embryos were actually transferred in North America compared to

South America (56.2% vs. 95.2%, respectively). Consequently, South America still ranks first in the number of transferred IVP embryos.

Differently from what is observed for IVD embryos, more IVP embryos were transferred fresh (66.1%). Yet, the proportion of fresh transfers of IVP embryos has been declining over the past years (89.8%, 81.3%, 74.0% and 72.9% for 2013, 2014, 2015 and 2016, respectively [Perry, 2017]).

Table 8. Transfer of bovine IVP embryos by region

Region/ Country	Embryos transferred							
	OPU				Abattoir			
	Fresh	Frozen		Total	Fresh	Frozen		Total
		Domestic	Foreign			Domestic	Foreign	
Africa	2,780	1,526	0	4,306	0	0	0	0
Asia	0	0	0	0	0	0	0	0
Europe	34,507	14,670	283	49,460	110	179	3	292
N America	167,674	91,892	329	259,895	7,741	0	0	7,741
Oceania	3,500	400	0	3,900	0	0	0	0
S America	284,387	147,666	0	432,053	5	0	0	5
Total	492,848	256,154	612	749,614	7,856	179	3	8,038

The numbers of IVD and of IVP embryos collected and transferred in 2017 in species other than bovine are shown in Tables 9 (small ruminants) and 10 (horses, cervids, swine, buffalo). In 2017, the embryo industry was very active in horses and sheep, with a total of 22,143 and 18,718 embryos produced, respectively (IVD+IVP).

Table 9. Small ruminants: IVD and IVP embryo collections and transfers

Region/ Country	IVD Embryos					IVP embryos					
	Flushes	Embryos	Embryo transfer			Donors	Oocytes	Embryos	Embryo transfer		
			Fresh	Frozen					Fresh	Frozen	
				Domestic	Foreign					Domestic	Foreign
Sheep											
Argentina	90	448	281	124	0	0	0	0	0	0	0
Brazil	1,100	8,816	4,338	2,892	0	0	0	0	0	0	0
Canada	133	1,259	46	0	0	0	0	0	0	0	0
France	10	33	0	0	0	0	0	0	0	0	0
Hungary	5	39	0	0	45	0	0	0	0	0	0
S Africa	2	127	127	0	0	0	0	0	0	0	0
Sweden	20	67	0	67	365	0	0	0	0	0	0
UK	1,018	6,296	3,503	328	0	0	0	0	0	0	0
USA	292	1,567	445	10	0	195	66	55	0	0	0
Total	2,670	18,652	8,740	3,421	410	0	195	66	55	0	0
Goats											
Brazil	82	793	568	225	0	0	0	0	0	0	0
Canada	9	91	70	12	0	0	0	0	0	0	0
France	9	76	0	0	0	0	0	0	0	0	0
UK	0	0	0	0	85	0	0	0	0	0	0
USA	413	3,015	2,438	191	0	201	61	0	0	0	0
Total	513	3,975	3,076	428	85	0	201	61	0	0	0

Within this group of species, the sheep had ET records in more regions (Africa, Europe, North America, South America). There are records on the use of IVEP in sheep and goats, but only in North America. Europe leads the use of IVEP in horses. The number of IVP embryos in this species increased significantly in 2017, accounting for 6.4% of all embryos produced in horses. It is also noteworthy that, for buffalos, only IVP embryos were recorded.

Table 10. Other species: IVD and IVP embryo collections and transfers

Region/ Country	IVD Embryos					IVP embryos					
	Flushes	Embryos	Embryo transfer			Donors	Oocytes	Embryos	Embryo transfer		
			Fresh	Frozen					Fresh	Frozen	
				Domestic	Foreign					Domestic	Foreign
Horses											
Brazil	31,650	19,560	19,210	0	0	225	900	180	115	0	0
Canada	19	11	6	3	0	0	0	0	0	0	0
Finland	4	1	1	0	0	0	0	0	0	0	0
France	1,476	776	776	0	0	0	0	0	0	0	0
Italy	289	197	197	0	0	934	10,866	885	82	203	0
Netherl.	284	164	164	0	0	213	2,807	241	0	140	0
Poland	7	7	7	0	0	0	0	0	0	0	0
Russian F.	3	2	2	4	0	0	0	0	0	0	0
Spain	15	12	12	0	0	0	0	0	0	0	0
Sweden	23	15	15	0	0	0	0	0	0	0	0
Switzerl.	72	37	30	2	0	56	215	16	0	3	0
USA	60	39	39	0	0	0	0	0	0	0	0
Total	33,902	20,821	20,459	9	0	1,428	14,788	1,322	197	346	0
Cervids											
Argentina	14	78	78	72	0	0	0	0	0	0	0
Mexico	64	125	0	0	0	0	0	0	0	0	0
USA	17	61	20	0	0	0	0	0	0	0	0
Total	95	264	98	72	0	0	0	0	0	0	0
Buffalo											
Italy	0	0	0	0	0	3	66	26	0	0	0
Swine											
USA	2	16	43	0	0	0	0	0	0	0	0
Other											
Slovakia	10	20	0	0	0	0	0	0	0	0	0

Data of embryos micro-manipulated for sexing or genotyping in 2017 is shown in Table 11. Data is limited to bovine and to Europe and North America, but it is likely that these numbers are underestimated, as many countries in other regions are unable to collect such data due to local differences in the way ET information is recorded.

The number of embryos exported are shown in Table 12. In 2017, 32,746 bovine embryos were exported, from which 81.3% (26,613) were IVD and 18.7% (6,133) were IVP. As expected, no embryos produced using abattoir-derived oocytes were exported. In sheep, 969 IVD embryos were exported by Canada.

Table 11. Micro-manipulation of bovine embryos for sexing and/or genotyping

Country	Sexed		Genotyped	
	IVD	IVP	IVD	IVP
Canada	678	563	0	563
France	2,491	0	2,388	0
Germany	768	73	367	19
Netherlands	0	0	164	1,080
Russian Federation	0	430	0	0
United States	0	56	0	19
Total	3,937	1,122	2,919	1,681

Table 12. Countries exporting embryos

Region/ Country	Bovine					Sheep
	IVD			IVP		IVD
	Dairy	Beef	Unsorted	OPU	Abattoir	
Australia	0	576	0	0	0	0
Austria	274	5	0	0	0	0
Belgium	35	58	0	0	0	0
Denmark	51	0	0	0	0	0
Finland	53	0	0	0	0	0
France	250	304	0	433	0	0
Luxembourg	50	0	0	0	0	0
Netherlands	1,701	0	0	1,094	0	0
Norway	0	40	0	0	0	0
Spain	43	0	160	0	0	0
Switzerland	97	0	0	0	0	0
United Kingdom	0	119	0	0	0	0
Canada	4,830	4,319	0	591	0	969
United States	7,119	3,913	0	4,015	0	0
Argentina	542	2,074	0	0	0	0
Total	15,045	11,408	160	6,133	0	969

4.2 Historical series and trends

The availability of consistent records throughout the years is critical for the creation of a historical time series, thus this section will focus on cattle data only. However, it is likely that some of the trends observed in the bovine embryo industry may occur in other species in a similar fashion.

Figure 2 shows the world cattle embryo production (IVD, IVP, and total) in the past 20 years. In 2016, the number of IVP embryos passed the number of IVD; however, the difference increased substantially in 2017. The main reason for this change was the exponential growth in the number of IVP embryos from the United States in the past few years, as well as a significant increase of IVP in Europe, in 2017 (Figure 3). The divergent trends for the numbers of IVD and IVP embryos are reflected in the accumulated numbers of embryos transferred from 1998 to 2017, as shown in Figure 4.

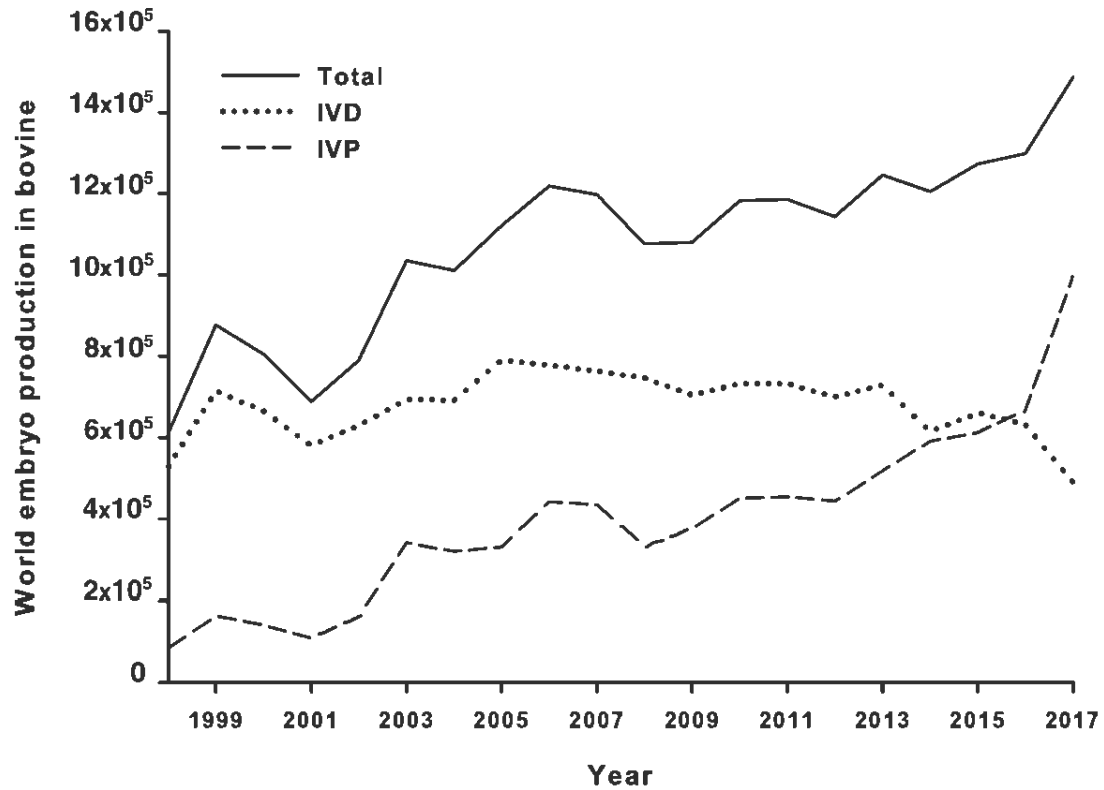


Figure 2. Number of bovine embryos (IVD, IVP, and total) recorded in the period 1998-2017

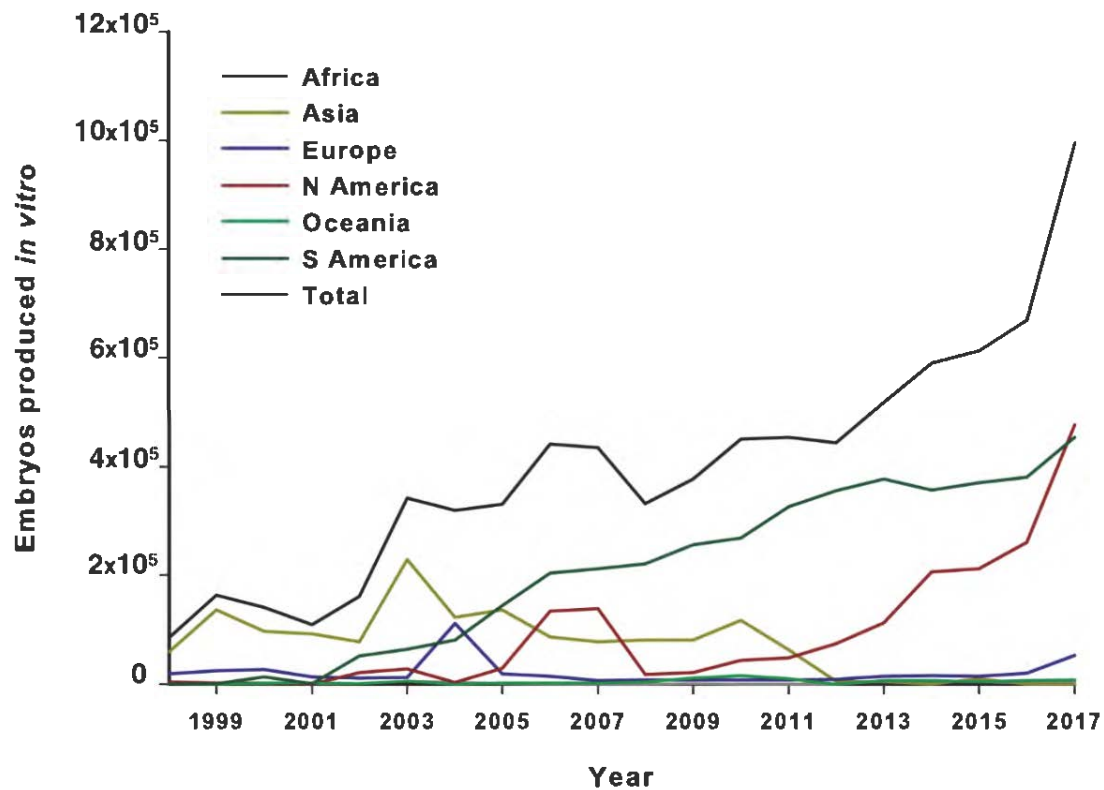


Figure 3. Number of IVP bovine embryos in the period of 1998-2017, by region

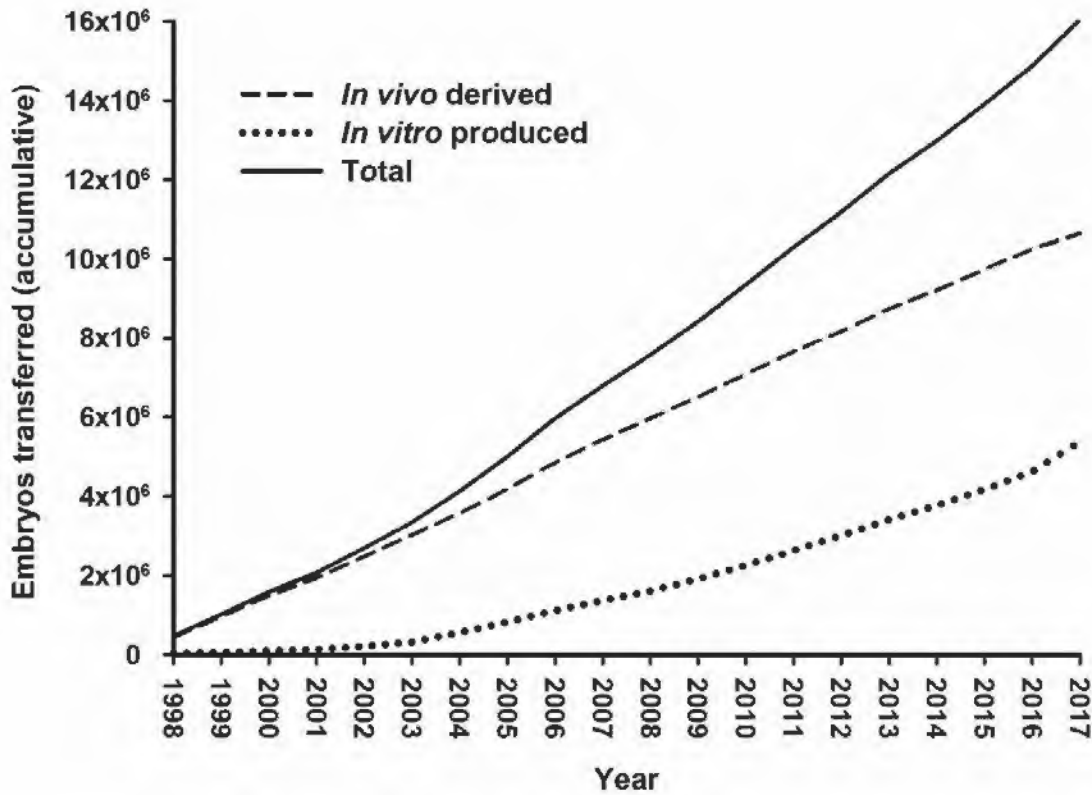


Figure 4. Accumulated number of bovine embryos transferred in the period 1998-2017, based on production method (*in vivo* or *in vitro*)

5. Discussion

The most remarkable change in the world embryo industry in 2017 was the fact that *in vitro* fertilization passed *in vivo* collection as the main source of bovine embryos, considering both embryo production and transfer. This shift has been previously observed in specific countries or regions, but this year for the first time it became a global trend. In 2016, the total number of IVP was greater than IVD embryos, though by a small difference (5.3%), and actually more IVD embryos were transferred that year.

Based on the trends of the past few years, it was predictable that, in 2017, the number of IVP embryos produced would be consistently greater than IVD. A projection using regression analysis on data from 2007 to 2016 estimated approximately 605,550 IVD and 751,044 IVP embryos for 2017, respectively, i.e., 24.0% more IVP than IVD embryos. According to the data retrieved this year, however, the real difference was far greater than projected (495,054 vs. 992,289 for IVD and IVP, respectively; a 2-fold difference). The main cause of the unexpected numbers was the exponential growth of IVEP in North America. The number of IVP embryos grew consistently in the past 10 years in that country, but the increase from 2016 to 2017 was outstanding (from 260,574 to 449,267; +72.4%), anticipating values expected only for 2018 or 2019. A significant increase in the use of IVP embryos was also observed in Europe (from 19,974 in 2016 to 52,879 in 2017; +164.7%). Its impact on global numbers, however, was lower. The Russian Federation produced 26,762 IVP embryos, accounting for 51.5% of Europe's total (Appendix 4). On the other hand, Brazilian numbers remained stable (345,528 in 2017 vs. 346,817 in 2016; -0.4%), probably still reflecting the economic crisis and recession of 2014-2016.

The 2017 numbers confirm the trend for a shift from IVD to IVP embryos in the USA. A similar phenomenon was previously observed elsewhere, such as Brazil in 2006 and

in 2012. Transient increases on IVEP, with eventual predominance of IVP over IVD embryos, were previously reported in Asia and Europe in the early 2000's (Thibier 2004, 2005). However, it was in South American countries that IVEP first turned out to be the main technique for embryo production for a long period of time. In Brazil, for example, this has been the main source of bovine embryos for over a decade and there is no evidence that this could change in the near future. The current trends in North America suggest that the further development of the embryo industry in that country may resemble what happened in South America (see Viana et al. 2018). For example, in both Brazil and Argentina, the increase in the use of IVP embryos was not associated to a proportional decrease in the use of IVD embryos, resulting in a greater total embryo production. In the period of 1998-2017, a total of 16,037,300 bovine embryos were transferred worldwide. As demonstrated in Figure 4, the contribution of IVD embryos for this total has been linear, and the emerging use of IVP embryos resulted in a substantial increase in numbers.

The difference observed between the number of IVD and IVP embryos recorded in 2017 may also have been indirectly affected by data recovery. The collection of comprehensive ET data from some but not all regions may bias the interpretation of global trends for the embryo industry, because of regional differences in the proportion of IVD and IVP embryos. For example, this year we were able to gather data from a number of countries with known active embryo industries, but that did not submit data in previous years, especially in South America. Some of them, such as Colombia and Paraguay, reported a high number of IVP embryos (24,503 and 26,044, respectively), contributing significantly to the increase in world's IVP total. Conversely, we did not receive data from countries that historically produced more IVD embryos. In Japan, for example, the national collector was unable to submit data due to changes in the national procedures to record ET data. In 2016, Japan reported 112,406 IVD embryos, which accounted for 17.8% of the world total. Assuming that there was no major change in the Japanese embryo industry, differences between the global number of IVD embryos predicted by regression analysis for 2017 (605,550) and the number actually reported (486,507) corresponds to the expected contribution of Japan (approximately 100,000 embryos). Thus, the lack of data from Asia probably explains most of the drop in IVD numbers in 2017, compared to 2016 (-23.1%).

Gaps in data collection have been a major challenge for this committee over the years. They result in underestimation and, most importantly, artificial fluctuations in the historical series, disturbing the characterization of trends and interpretation of the actual scenario. In this regard, the presence of national or regional embryo transfer associations have been extremely important, either to organize data collection or to encourage data report by ET teams. In the lack of such associations, data retrieval depends on the direct report by local practitioners. This is the case of Australia and New Zealand, where most ET teams show reluctance in submitting data to the IETS. In this regard, improving data collection from Asia and Oceania, as well as for species other than bovine, must be specific goals for this committee in the next years.

It is noteworthy that the current trends of the embryo industry may have a further impact on ET data retrieval. Embryo production *in vivo* is frequently performed in low scale and by scattered teams or practitioners, what makes data collection harder. Conversely, IVEP tends to be used in larger scales but by fewer companies, and thus data collection is easier. Thus, the increasing use of IVP embryos may reduce the underestimation in global numbers. Nonetheless, this trend will have no influence on under-reporting of IVD embryos and, consequently, the differences between the numbers of IVP and IVD embryos may end up overestimated.

6. Acknowledgements

The Data Retrieval Committee sincerely thank Dr. George Perry for his work as the former chair of this committee, who stepped out last year but fully supported our job during

this transition. We also gratefully acknowledge the efforts of all regional data collectors, some among them providing very detailed data reports, as well as all practitioners or representatives of ET companies who reported data directly to the database. The comprehensiveness of the present report is the result of the volunteer collaboration of all these colleagues.

7. References

- Food Agriculture Organization (FAO). 2017 Cattle inventory. Available on: <http://www.fao.org/faostat/en/#data/QA>.
- Perry G. 2014. 2013 statistics of embryo collection and transfer in domestic farm animals. *Embryo Transfer Newsl*, 32(4):14-24.
- Perry G. 2017. 2016 statistics of embryo collection and transfer in domestic farm animals. *Embryo Transfer Newsl*, 35(4):08-23.
- Thibier M. 2004. Stabilization of numbers of *in vivo* collected embryos in cattle but significant increases of in vitro bovine produced embryos in some parts of the world. *Embryo Transfer Newsl*, 22(4):12-19.
- Thibier M. 2005. Significant increases in transfers of both *in vivo* derived and in vitro produced embryos in cattle and contrasted trends in other species in 2004. *Embryo Transfer Newsl*, 23(4):11-17.
- Viana JHM et al. A historical perspective of embryo-related technologies in South America. *Anim. Reprod* 15: 963-970, 2018. DOI: 10.21451/1984-3143-AR2018-0016

Appendix 1: National data collectors

Region/Country	Collector	Region/Country	Collector
Africa		Europe	
Kenya	Joao Viana	AETE	Marja Mikkola
Mozambique	Joao Viana	Austria	Friedrich Führer
Namibia	Morne de la Rey	Belgium	Peter Vercauteren, Isabelle Donnay
Rep South Africa	Morne de la Rey	Bosnia Herzegovina	Teodor Markovic
		Croatia	Mario Matkovic
Asia		Czech Republic	Pavel Bucek
Israel	Amir Shifman, Yoel Zeron	Denmark	Henrik Callesen
Japan	Osamu Dochi	Estonia	Jevgeni Kurykin
		Finland	Seija Vahtiala
Central America		France	Serge Lacaze
Panama	Luis Nasser	Germany	Hubert Cramer
Dominican Rep	Luis Nasser	Greece	Foteini Samartzi
		Hungary	Istvan Pentek
North America		Ireland	Patrick Lonergan
Canada	Reuben Mapletoft (CETA)	Italy	Giovanna Lazzari
Mexico	Salvador Romo	Latvia	Vita Antane
United States	Daniela Demetrio (AETA)	Lithuania	Rasa Nainiene
		Luxembourg	Marianne Vaessen
South America		Macedonia	Toni Dovenski
Argentina	Gabriel Bo	The Netherlands	Helga Flapper, Hilde Aardema
Brazil (bovine)	Joao Viana	Norway	Eiliv Kummen
Brazil (equine)	Marco Alvarenga	Poland	Jędrzej Jaśkowski
Brazil (small rum)	Jeferson Fonseca, Joanna Souza	Portugal	João Nestor Chagas e Silva
Bolivia	Joao Viana	Russian Federation	Denis Knurow, Viktor Madison
Colombia	Joao Viana	Serbia	Aleksandar Milovanovic
Paraguay	Gabriel Bo	Slovakia	Jozef Bires, Dalibor Polak
Peru	Edwin Mellisho	Slovenia	Janko Mrkun
Uruguay	Sergio Kmaid	Spain	Daniel Martinez Bello
Venezuela	Joao Viana	Sweden	Renée Båge
		Switzerland	Rainer Saner
Oceania		Turkey	Ebru Emsen
Australia	George Perry	Ukraine	Viktor Madison
		United Kingdom	Roger Sturmey, Brian Graham

Appendix 2: Bovine in-vivo derived embryo collection by region and countries

Region/ Country	Flushes						Collected					
	Conventional semen			Sexed semen			Total ova			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa												
Namibia	0	13	13	0	0	0	0	118	118	0	65	65
Rep South Africa	32	686	718	0	0	0	539	5,410	5,949	333	4,728	5,061
Asia												
Israel	58	0	58	2	0	2	382	0	382	212	0	212
Europe												
Austria	242	19	261	10	0	10	2,486	211	2,697	1,821	193	2,014
Belgium	141	1,015	1,156	4	0	4	1,175	6,453	7,628	696	5,277	5,973
Denmark	701	58	759	0	0	0	6,325	559	6,884	4,294	491	4,785
Finland	299	2	301	9	0	9	2,780	16	2,796	1,934	15	1,949
France	4,491	1,294	5,785	871	73	944	47,703	13,893	61,596	28,105	7,172	35,277
Germany	3,031	381	3,412	0	0	0	30,414	4,083	34,497	20,297	2,585	22,882
Hungary	7	36	43	11	6	17	124	385	509	116	255	371
Ireland	785	0	785	0	0	0	9,688	0	9,688	4,328	0	4,328
Italy	1,350	150	1,500	1,000	0	1,000	27,495	1,575	29,070	18,800	1,083	19,883
Latvia	6	0	6	0	0	0	0	0	0	0	0	0
Lithuania	4	0	4	0	0	0	32	0	32	23	0	23
Luxembourg	179	10	189	23	0	23	1,665	100	1,765	1,081	70	1,151
Netherlands	2,493	0	2,493	0	0	0	24,760	0	24,760	21,910	0	21,910
Norway	37	23	60	0	0	0	0	0	0	260	110	370
Poland	124	7	131	88	7	95	1,746	93	1,839	1,131	46	1,177
Portugal	44	31	75	27	0	27	943	216	1,159	408	102	510
Russian Fed.	175	1,191	1,366	397	92	489	7,496	12,857	20,353	2,688	10,144	12,832
Serbia	6	0	6	0	0	0	47	0	47	25	0	25
Slovenia	11	0	11	0	0	0	46	0	46	33	0	33
Spain	141	162	303	228	20	248	3,382	1,818	5,200	1,866	1,064	2,930
Sweden	127	3	130	0	0	0	864	4	868	562	2	564
Switzerland	246	30	276	267	0	267	5,779	396	6,175	3,649	262	3,911
Ukraine	10	0	10	0	0	0	50	0	50	21	0	21
United Kingdom	4	54	58	3	0	3	60	521	581	47	280	327
N America												
Canada	4,863	2,917	7,780	1,776	4	1,780	73,591	40,262	113,853	42,231	22,914	65,145
Mexico	20	739	759	0	0	0	45	3,284	3,329	45	3,284	3,329
United States	10,063	24,252	34,315	0	0	0	99,076	307,511	406,587	57,708	166,573	224,281
Oceania												
Australia	0	1,029	1,029	0	6	6	0	6,593	6,593	0	4,485	4,485
S America												
Argentina	290	2,981	3,271	0	0	0	2,444	31,684	34,128	1,412	16,290	17,702
Brazil	3,968	1,346	5,314	0	0	0	22,385	7,590	29,975	22,385	7,148	29,533
Peru	61	72	133	0	0	0	225	169	394	902	360	1,262
Uruguay	12	102	114	0	0	0	98	1,129	1,227	59	674	733

Appendix 3: Bovine in-vivo derived embryos transferred by region and countries

Region/ Country	Fresh embryos			Frozen domestic embryos			Frozen imported embryos					
	Dairy	Beef	Unsorted	Total	Dairy	Beef	Unsorted	Total	Dairy	Beef	Unsorted	Total
Africa												
Namibia	45	0	0	45	23	0	0	23	116	0	0	116
Rep South Africa	49	2220	0	2269	54	1982	0	2036	0	1259	0	1259
Asia												
Israel	192	0	0	192	8	0	0	8	0	0	0	0
Europe												
Austria	640	12	0	652	824	95	0	919	77	27	0	104
Belgium	173	995	0	1,168	493	3,017	0	3,510	1,616	34	0	1,650
Denmark	2,494	129	0	2,623	1,253	124	0	1,377	0	0	0	0
Finland	722	9	0	731	1,484	1	0	1,485	212	33	0	245
France	14,216	2,630	56	16,902	12,668	4,548	0	17,216	1,615	289	0	1,904
Germany	8,047	717	0	8,764	11,078	1,351	0	12,429	0	0	0	0
Greece	0	0	0	0	0	0	0	0	2	0	0	2
Hungary	60	29	0	89	58	129	0	187	0	0	0	0
Ireland	1,698	0	0	1,698	2,155	0	0	2,155	0	0	0	0
Italy	7,400	0	0	7,400	0	0	0	0	0	0	0	0
Luxembourg	280	20	0	300	800	70	0	870	35	0	0	35
Netherlands	6,303	0	0	6,303	17,867	0	0	17,867	0	0	0	0
Norway	35	25	0	60	142	28	0	170	0	113	0	113
Poland	760	20	0	780	288	3	0	291	123	0	0	123
Portugal	92	31	0	123	339	32	0	371	0	13	0	13
Russian Federation	823	45	0	868	1,484	11,334	0	12,818	24	0	0	24
Serbia	10	0	0	10	15	0	0	15	0	0	0	0
Slovenia	13	0	0	13	5	0	0	5	0	8	0	8
Spain	453	403	664	1,520	485	147	471	1,103	59	21	56	136
Sweden	205	2	0	207	412	0	0	412	0	0	0	0
Switzerland	1,012	32	0	1,044	2,152	69	0	2,221	622	32	0	654
Ukraine	21	0	0	21	0	0	0	0	0	0	0	0
United Kingdom	21	57	0	78	23	116	0	139	8	37	0	45
N America												
Canada	13,494	3,254	0	16,748	17,594	8,904	0	26,498	18	548	0	566
Mexico	0	1,840	0	1,840	0	941	0	941	0	92	0	92
United States	23,415	45,974	0	69,389	21,307	79,736	0	101,043	35	6	0	41
Oceania												
Australia	0	2,113	0	2,113	0	1,935	0	1,935	0	404	0	404
S America												
Argentina	1,139	4,613	0	5,752	1,611	7,986	0	9,597	58	20	0	78
Brazil	7,177	4,026	0	11,203	15,208	3,122	0	18,330	0	0	0	0
Peru	33	76	0	109	9	0	0	9	18	35	0	53
Uruguay	95	363	458	916	36	163	199	398	0	157	157	314

Appendix 4: Bovine OPU-IVEP by region and countries

Region/ Country	Donor preparation						Oocytes						Transferrable embryos					
	Non-stimulated			Stimulated			Non-stimulated			Stimulated			Non-stimulated			Stimulated		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa																		
Kenya	169	38	207	0	0	0	258	63	321	0	0	0	77	21	98	0	0	0
Mozambique	658	160	818	0	0	0	1,841	724	2,565	0	0	0	610	455	1,065	0	0	0
Rep South Africa	0	1,435	1,435	0	0	0	0	20,014	20,014	0	0	0	0	4,217	4,217	0	0	0
Centr America																		
Panama	808	430	1,238	0	0	0	6,458	7,751	14,209	0	0	0	907	1,390	2,297	0	0	0
Dominican Rep	291	385	676	0	0	0	6,494	9,438	15,932	0	0	0	1,654	2,519	4,173	0	0	0
Europe																		
Finland	103	0	103	352	0	352	734	0	734	3,014	0	3,014	163	0	163	1,048	0	1,048
France	6	1	7	655	29	684	31	6	37	5,717	417	6,134	19	3	22	1,597	137	1,734
Germany	440	17	457	563	0	563	5,315	225	5,540	8,340	0	8,340	656	27	683	1,111	0	1,111
Italy	378	0	378	104	0	104	3,781	0	3,781	1,038	0	1,038	632	0	632	186	0	186
Netherlands	0	0	0	7,345	0	7,345	0	0	0	83,421	0	83,421	0	0	0	16,695	0	16,695
Poland	14	0	14	0	0	0	89	0	89	0	0	0	34	0	34	0	0	0
Russian Fed.	3,271	4,487	7,758	0	0	0	25,579	61,541	87,120	0	0	0	3,682	23,080	26,762	0	0	0
Spain	633	105	738	89	12	101	8,409	1,256	9,665	1,337	120	1,457	1,747	447	2,194	494	58	552
Switzerland	41	0	41	0	0	0	312	0	312	0	0	0	81	0	81	0	0	0
United Kingdom	3	36	39	0	0	0	31	384	415	0	0	0	7	67	74	0	0	0
N America																		
Canada	0	0	0	2,852	206	3,058	0	0	0	41,252	2,754	44,006	0	0	0	19,004	1,385	20,389
Mexico	8,964	2,517	11,481	0	0	0	132,422	72,672	205,094	0	0	0	14,553	12,149	26,702	0	0	0
United States	46,847	3,302	50,149	32,640	20,138	52,778	729,422	58,812	788,234	541,118	452,620	993,738	107,330	16,022	123,352	170,980	126,805	297,785
Oceania																		
Australia	0	833	833	0	0	0	0	18,003	18,003	0	0	0	0	4,332	4,332	0	0	0
S America																		
Argentina	975	6,428	7,403	0	0	0	8,321	129,406	137,727	0	0	0	1,710	31,034	32,744	0	0	0
Brazil	32,498	30,010	62,508	0	0	0	601,583	412,632	1,014,215	0	0	0	180,475	165,053	345,528	0	0	0
Bolivia	90	408	498	0	0	0	1,431	9,291	10,722	0	0	0	390	3,861	4,251	0	0	0
Colombia	7,223	2,069	9,292	0	0	0	137,208	42,136	179,344	0	0	0	24,503	8,412	32,915	0	0	0
Paraguay	0	4,371	4,371	0	0	0	0	67,890	67,890	0	0	0	0	26,044	26,044	0	0	0
Venezuela	146	351	497	0	0	0	1,945	6,669	8,614	0	0	0	505	2,156	2,661	0	0	0

Appendix 6: Bovine IVP embryo transfer by region and countries

Region/ Country	Embryos transferred							Exported
	OPU			Total	Fresh	Abattoir		
	Fresh	Frozen Domestic	Foreign			Frozen	Total	
Africa								
Kenya	63	22	0	85	0	0	0	0
Mozambique	331	474	0	805	0	0	0	0
Rep South Africa	2,386	1,030	0	3,416	0	0	0	0
Centr America								
Panama	1,947	350	0	2,297	0	0	0	0
Dominican Rep	1,035	1,177	0	2,212	0	0	0	0
Europe								
Finland	49	798	0	847	0	0	0	0
France	815	329	49	1,193	19	3	0	22
Germany	1,508	174	0	1,682	0	0	0	0
Hungary	0	0	105	105	0	0	0	0
Italy	212	503	0	715	0	42	0	42
Netherlands	10,196	4,731	0	14,927	63	114	0	177
Poland	16	7	0	23	0	0	0	0
Russian Fed.	20,302	7,658	0	27,960	0	0	0	0
Spain	1,407	448	12	1,867	28	20	3	51
Switzerland	2	7	117	126	0	0	0	0
United Kingdom	0	15	0	15	0	0	0	0
N America								
Canada	6,385	2,813	323	9,521	0	0	0	0
Mexico	8,471	10,479	0	18,950	0	0	0	0
United States	152,818	78,600	6	231,424	7,741	0	0	7,741
Oceania								
Australia	3,500	400	0	3,900	0	0	0	0
S America								
Argentina	18,933	8,032	0	26,965	0	0	0	0
Brazil	227,939	115,872	0	343,811	0	0	0	0
Bolivia	3,043	0	0	3,043	0	0	0	0
Colombia	23,736	2,913	0	26,649	0	0	0	0
Paraguay	6,195	19,036	0	25,231	0	0	0	0
Peru	0	0	0	0	5	0	0	5
Venezuela	1,559	286	0	1,845	0	0	0	0