

2022 Statistics of embryo production and transfer in domestic farm animals

The main trends for the world embryo industry still stand

By Joao H. M. Viana, Chair – IETS Data Retrieval Committee (henrique.viana@embrapa.br)
In: Embryo Technology Newsletter, v. 41, n.4, 2023

1. Executive summary

The Data Retrieval Committee of the International Embryo Technology Society (IETS) presents their 32nd Annual Report of data collected worldwide in 2023 on embryo transfer (ET) activities during the year 2022. In general, the main trends for the world embryo industry have not changed much, and numbers continue to increase, albeit at a lower rate than previously observed for the period 2020–2021.

The number of countries reporting data slightly increased in 2022 (43 vs 40 in 2021) and included two countries from Asia (Table 1). Nevertheless, this minor change had little impact on the world total and, thus, did not significantly affect the main trends of the world embryo industry. Based on embryo export records, we were able to detect embryo transfer activity in 10 other countries that did not report any data to this committee. Altogether, these records suggest that embryo technologies are currently used by 27.6% of the countries worldwide.

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

Region	Cattle		Other (IVD + IVP) ¹				% Countries within a region ²
	IVD	IVP	Horses	Sheep	Goats	Other ³	
Africa	1	1	0	0	0	0	1.9 (1/54)
Asia	1	2	0	0	0	0	4.3 (2/47)
Europe	23	18	9	6	2	3	61.0 (25/41)
North America	3	3	2	3	2	2	100.0 (03/03)
Oceania	1	1	0	1	1	0	7.1 (1/14)
South America ⁴	3	10	2	3	1	2	33.3 (11/33)
Total	31	35	13	13	6	7	22.4 (43/192)

¹IVD: *in vivo* derived; IVP: *in vitro* produced.

²Based on the number of countries with records of livestock in the FaoStat database.

³Cervids, camelids, buffalo, swine.

⁴South America, Central America, and the Caribbean.

The data of the embryo industry in 2022 on the four most representative farm animal species are summarized in Table 2 (total of embryos, produced or collected) and Table 3 (number of transferred embryos). A total of 2,113,036 embryos were collected or produced in farm animals; 95.2% of those were cattle, 2.0% sheep, 1.8% horses, 0.9% goats, and 0.03% other species such as cervids, buffalo, camelids, and pigs. As observed in the past few years, the global embryo market remained warmed and the total number of embryos recorded increased in 2022, compared with 2021, in the main farm animal species: +5.5% in cattle, +3.3% in sheep, +3.8% in horses, and +10.1% in goats. In all cases, however, the rate of increase was less than the one observed in the period 2020 to 2021. In cattle, for example, the number of *in vitro* produced (IVP) embryos increased by +2.1%, and the number of collected *in vivo* derived (IVD) embryos increased +6.3%, compared with 2021. In the period 2020 to 2021, those rates were +7.3% and +31.5%, respectively. Nevertheless, the overall increase (+5.5%) represents an additional 104,088 embryos recorded in cattle compared with 2021. The trend toward an increase in bovine embryo production in 2022 were observed for all regions, even though they

varied from country to country within a given region. Worldwide, IVP embryos accounted for, in 2022, 80.4% of all transferrable cattle embryos.

We observed similar trends in sheep, with both numbers of IVD and IVP embryos increasing in 2022 compared with 2021 (+3.1% and +12.5%, respectively), but at a much lower degree than that observed from 2020 to 2021 (+38.1% and +344.0%, respectively). In horses, the number of IVD embryos recorded in 2022 decreased (−4.8%), but that was compensated by an increase in IVP activity (+22.6%) resulting in an overall increase in total numbers, compared with 2021 (+3.8%). In goats, on the other hand, the number of IVP embryos decreased (−66.2%), whereas the number of IVD embryos increased (+53.4%), compared with 2021.

Table 2. Total production (transferrable embryos) of IVD and IVP embryos¹ in 2022 in cattle, sheep, goats, and horses, by region

Region	Cattle		Horses		Sheep		Goats	
	IVD	IVP	IVD	IVP	IVD	IVP	IVD	IVP
Africa	2,027	7,377	0	0	0	0	0	0
Asia	1,764	14,733	0	0	0	0	0	0
Europe	137,036	43,749	109	7,153	1,332	6	46	0
North America	204,682	842,064	988	2,979	11,924	176	14,871	2,147
Oceania	12,455	20,633	0	0	22,255	486	2,051	0
South America	36,545	688,415	23,151	4,110	6,959	36	199	0
Total 2022	394,509	1,616,971	24,248	14,242	42,470	704	17,167	2,147
Total 2021	386,374	1,521,018	25,475	11,619	41,183	626	11,193	6,355
% Change	+2.1	+6.3	−4.8	+22.6	+3.1	+12.5	+53.4	−66.2

¹IVD: *in vivo* derived; IVP: *in vitro* produced.

The number of transferred IVP cattle embryos increased only +2.0% worldwide, compared with 2021 (1,189,699 vs 1,166,034 respectively), whereas the number of transferred IVD embryos increased +17.5%. Despite of the fact that IVD embryos represents 87.1% of all embryo transfers in Europe, this increase in the number of transferred IVD embryos in 2022 was driven mostly by North America (+19.2%) and South America (+82.8%), regions in which IVP embryos account for 71.3% and 94.0% of totals, respectively.

Frozen-thawed embryos represented 44.3% of the cattle IVP transfers in 2022, maintaining the trend toward a greater use of cryopreservation of IVP embryos (it was 41.3% in 2021 and 39.5% in 2020). The proportion of frozen-thawed IVD embryos also increased (64.8% vs 60.5%; 2022 vs 2021, respectively). Altogether, cryopreserved embryos now account for nearly half (49.1%) of all cattle embryos transferred worldwide.

Table 3. Transfers of IVD and IVP embryos in 2022 in cattle, sheep, goats, and horses, by region

Region	Cattle		Horses		Sheep		Goats	
	IVD	IVP	IVD	IVP	IVD	IVP	IVD	IVP
Africa	3,064	6,708	0	0	0	0	0	0
Asia	1,341	13,175	0	0	0	0	0	0
Europe	121,260	17,890	125	8,005	1,393	295	62	0
North America	192,882	479,610	950	3,994	11,720	234	14,278	1,748
Oceania	8,807	21,534	0	0	21,081	0	1,678	0
South America	41,429	650,782	21,944	8,220	6,593	0	468	0
Total 2022	368,783	1,189,699	23,019	20,219	40,787	529	16,486	1,748

Total 2021 %	313,780	1,166,034		26.205	6.078		66,840	446		10,295	5,602
Change	+17.5	+2.0		-12.2	+232.7		-39.0	+18.6		+60.1	-68.8

In summary, we observed no major changes for the main trends already detected in the world embryo industry. Yet, actual numbers grew at a lower rate compared with the one recorded from 2020 to 2021. Lastly, no significant changes in the regional features of the embryo industry other than the expected fluctuation in numbers among countries were detected.

2. Introduction

The Data Retrieval Committee (DRC) is the committee of IETS in charge of gathering, organizing, and publishing the statistics of the embryo industry in domestic farm animals. This year, we present our 32nd Annual Report showing data on global activities related to *in vivo* and *in vitro* embryo collection, production, and transfers in the year 2022. The results shown in the present report represents the main scenario of the embryo industry worldwide in ruminants and horses.

3. Methodology

Data collection followed the standard methodology used in previous years, as defined by the DRC and reported annually in the December issue of the Embryo Technology Newsletter. In summary, embryo technology activity in each country was either reported by a local data collector or reported individually by practitioners or commercial companies (e.g., *in vitro* embryo production [IVEP] laboratories). In several countries, the data collector is a member of 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 has been submitted by a regional collector on behalf of the Association of Embryo Technology in Europe (AETE). Data has also been reported to IETS by ET teams or companies working abroad. In a few countries, this was the sole source of information on embryo activity. In the case of similar data reported by a local representative, however, data coming from such teams or companies were discarded, to avoid double-reporting. The list of data collectors and local collaborators is shown in Appendix 1.

Data was directly uploaded into the IETS website by the national collector or sent to the Chair of the DRC. The software managing the database generate .csv files with data organized by criteria defined in the data submission form. A summary of the results is shown in Tables 4 to 14, by region, technology (*in vivo*-derived [IVD] or *in vitro*-produced [IVP]), and species. South American numbers include those collected from South and Central America countries. Data has also been used to build historical series and ranks, shown in Figures 2 to 5 and in Table 15. Detailed country information (Appendix 2 to 6), are available as supplemental files at the IETS website (www.iets.org/Committees/Data-Retrieval-Committee).

4. Results

Data retrieval

In 2022 we were able to recover data from two Asian countries (South Korea and Vietnam), as well as IVD data from South Africa. Although the totals obtained from these countries had limited impact on world trends, they represent an improvement in terms of comprehensiveness of our survey. In the other regions, minor changes were observed in the number of countries reporting ET data from cattle, sheep, horses, and goats in 2022. In Europe, we recovered data from 25 countries, which included in 2022 the Czech Republic, Hungary, and Türkiye. On the other hand, no data was obtained from Belarus and Estonia. Once again, Oceania was represented only by Australia. In South and Central America, the only changes were the lack of data from Costa Rica and the inclusion of Ecuador. The number of countries reporting cattle IVD embryos remained the same as for the year 2021 (31), whereas those reporting IVP embryos increased from 29 to 35. In sheep, a number of changes occurred and, differently from

Table 4. Collection of bovine *in vivo* derived [IVD] embryos by region in 2022
Collected

Region/ Country	Flushes			Ova			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa	0	271	271	0	3,382	3,382	0	2,027	2,027
Asia	0	303	303	0	2,293	2,293	0	1,764	1,764
Europe	18,746	6,906	25,652	162,782	43,452	206,234	112,425	24,611	137,036
North America	12,382	20,461	32,843	102,951	234,769	337,720	67,279	137,403	204,682
Oceania	188	2,633	2,821	1,574	7,450	9,024	686	11,769	12,455
South America	3,137	4,213	7,350	17,918	35,115	53,033	16,046	20,499	36,545
Total	34,453	34,787	69,240	285,225	326,461	611,686	196,436	198,073	394,509

North America still accounts for the majority of IVD embryos collected and transferred worldwide (51.9% and 52.3%, respectively, in 2022). Currently, IVD embryos represents only 17.3% of the total in the USA and 6.6% in Mexico. Canada is the single country in the region with more recorded IVD than IVP embryos (61.6% vs 38.4%, respectively). Conversely, superovulation remains as the main source of cattle embryos (87.1%) in Europe and is adopted by 23 out of the 25 countries reporting data for this species. In Europe, the majority of IVD embryos (82.0%) has been collected from dairy breeds, contrasting with what is observed in North America (32.9%), Oceania (5.5%), and South America (43.9%).

Superovulation efficiency remained relatively stable, with an estimated average of 8.8 ova and 5.7 transferable embryos *per* flush worldwide (those were 9.4 and 5.8, respectively, in 2021). Sex-sorted semen was used in 31.9% of flushes in dairy breeds, but in only 6.5% of the flushes in beef breeds, figures quite similar to those recorded in 2021 (31.7% and 4.9%, respectively). In 2022, we observed an increase in the proportions of transferred frozen-thawed IVD embryos (64.8% vs 60.5% in 2021). As observed in 2021, the transfer of cryopreserved embryos was greater in beef than dairy breeds (70.8% vs 58.6%).

Table 5. Transfers of bovine *in vivo* derived [IVD] embryos by region in 2022

Region/ Country	Fresh			Frozen domestic			Frozen imported			Total ET
	Dairy	Beef	Unsorted	Dairy	Beef	Unsorted	Dairy	Beef	Unsorted	
Africa	0	1,453	0	0	1,566	0	0	45	0	3,064
Asia	0	470	0	0	819	0	0	52	0	1,341
Europe	43,759	5,560	420	51,765	14,164	1,099	3,401	1,092	0	121,260
N America	18,794	35,220	0	41,414	96,558	0	265	631	0	192,882
Oceania	260	2,600	0	363	5,339	0	33	212	0	8,807
S America	12,563	8,867	0	9,325	10,617	0	42	15	0	41,429
Total	75,376	54,170	420	102,867	129,063	1,099	3,741	2,047	0	368,783

4.1.2 Cattle, IVP

The *in vitro* production of embryos in 2022 is shown in Table 6 (OPU-collected oocytes) and Table 7 (abattoir-derived oocytes). The number of IVP embryos reported worldwide increased, although not at the same proportion as observed in 2021 (+6.3% vs +31.5%, 2022 vs 2021, respectively). Nevertheless, IVP was the main driver of the overall growth in embryo activity in 2022 (+5.5%). Compared with 2021, the number of IVP embryos recorded in 2022 increased in all regions but South America, and the changes were particularly noticeable in North America (+10.1%). This scenario in North America was expected, considering the progression of USA numbers, which have grown consistently over the past decade (+564.0%

from 2013 to 2022) and reached a record 745,684 in 2022. Europe resumed the growth in IVP numbers (+3.2%), after experiencing a decrease from 2020 to 2021 (-10.7%), whereas numbers from South America remained relatively stable (-0.4%), after increasing +35.3% from 2020 to 2021.

Amongst the European countries with the most significant ET industry, the number of IVP embryos recorded in 2022 decreased in the Netherlands (-12.4%) and in the UK (-32.2%), but increased in Germany (+6.4%), Spain (+109.4%) and France (+8.7%). In South America, records of IVP embryos increased in Argentina (+15.8%), Bolivia (+3.3%) and Paraguay (+37.8%), stabilized in Brazil (+0.4%), and decreased in Chile (-26.6%), Colombia (-26.5%), Panama (-4.7%), Uruguay (-11.8%) and Venezuela (-85.4%).

As mentioned in the previous report [2], we have been monitoring other indirect markers of the ET industry activity in Brazil. For instance, the number of ET sheaths sold in 2022 was more than twice the number of embryo transfer records (997,765 vs 443,712, respectively), suggesting that the actual number of embryos produced and transferred might be significantly underestimated. This difference is likely to be associated with the market of low-cost embryos, which are usually not registered by the breeders' associations and, thus, not reported to the IETS. Therefore, we can speculate that the actual number of transferrable IVP embryos produced worldwide were probably over two million in 2022.

Table 6. Production of embryos *in vitro* with OPU-collected oocytes by region in 2022

Region/ Country	Donors			Oocytes			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa	0	1,575	1,575	0	26,334	26,334	0	7,377	7,377
Asia	1,332	2,434	3,766	14,520	28,824	43,344	2,781	8,608	11,389
Europe	12,910	407	13,317	147,085	5,718	152,803	34,440	1,651	36,091
N America	103,225	75,457	178,682	1,985,790	1,919,281	3,905,071	354,374	486,441	840,815
Oceania	163	4,743	4,906	564	96,162	96,726	167	20,464	20,631
S America	81,147	60,847	141,994	1,039,690	1,235,132	2,274,822	300,191	378,710	678,901
Total	198,777	145,463	344,240	3,187,649	3,311,451	6,499,100	691,953	903,251	1,595,204

In general, FSH stimulation before ovum pick-up (OPU) in 2022 was used in 40.7% of the donors-OPU sessions, and most commonly adopted for dairy than beef breeds (43.8% vs 36.6%, respectively). Some countries, however, do not report data stratified to register the use of FSH stimulation and, thus, these percentages may be underestimated. In Europe and North America, most OPU were carried out after FSH stimulation (88.0% and 69.2%, respectively), whereas in Oceania and South America FSH is rarely used (4.2% and 3.2%, respectively). This difference may be related with the proportion of dairy and beef breeds undergoing OPU as well as *Bos taurus* or *Bos indicus* population within these regions.

Table 7. Production of embryos *in vitro* with abattoir-derived oocytes by region in 2022

Region/ Country	Donors			Oocytes			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa	0	0	0	0	0	0	0	0	0
Asia	169	530	699	3,095	7,421	10,516	938	2,406	3,344
Europe	414	1,023	1,437	29,878	20,647	50,525	3,499	4,159	7,658
N America	235	186	421	2,437	3,617	6,054	386	863	1,249
Oceania	0	1	1	0	4	4	0	2	2
S America	0	1,585	1,585	0	31,713	31,713	0	9,514	9,514
Total	818	3,325	4,143	35,410	63,402	98,812	4,823	16,944	21,767

The overall number of IVP embryos produced using abattoir-derived oocytes in 2022 remained stable (-0.5%; 21,767 vs 21,882 in 2021), and this trend was observed in all regions (Table 7). The proportion of IVP embryos generated from abattoir oocytes remains very low (1.3% of total) and quite similar to the one recorded in 2021 (1.4%).

The number of transfers of IVP embryos in 2022 is shown in Table 8. Although the absolute number of IVP embryo transfers increased, the proportion of IVP embryos produced and actually transferred in 2022 decreased compared with 2021 (1,189,699 [73.6%] vs 1,166,034 [76.7%], respectively). The proportion of IVP embryos actually transferred was particularly low in Europe (40.9%) and North America (57.0%), whereas in Africa, Oceania, and in South America, more than 90% of the IVP embryos produced were transferred within the same year. Brazil remains as the leading country in transfers of IVP embryos worldwide (440,256, corresponding to 37.0% of the world total), in spite of reporting a lesser number of IVP embryo production than the USA (443,712 vs 745,684; Brazil vs USA, respectively). The proportion of frozen-thawed IVP embryos transferred in 2022 increased relative to 2021 (44.2% vs 41.3%, respectively), which is consistent with the what has been observed over the last years. Frozen-thawed IVP embryos accounted for 33.7% of all embryo transfers in cattle.

Table 8. Transfer of bovine *in vitro* produced (IVP) embryos by region in 2022

Region/ Country	Embryos transferred							
	OPU				Abattoir			
	Fresh	Frozen Domestic	Frozen Foreign	Total	Fresh	Frozen Domestic	Frozen Foreign	Total
Africa	2,135	4,573	0	6,708	0	0	0	0
Asia	6,089	4,174	125	10,388	1,476	1,311	0	2,787
Europe	7,564	7,484	397	15,445	1,404	1,041	0	2,445
N America	258,890	219,658	199	478,747	548	315	0	863
Oceania	14,679	6,804	51	21,534	0	0	0	0
S America	367,575	276,026	2,604	646,205	3396	1181	0	4577
Total	656,932	518,719	3,376	1,179,027	6,824	3,848	0	10,672

Data regarding embryos micromanipulated for sexing or genotyping in 2022 is shown in Table 9. We observed a decline in all categories compared with 2021 (-69.0%, -18.6%, -42.1%, and -17.5% for IVD sexed, IVP sexed, IVD genotyped and IVP genotyped, respectively). The countries reporting embryo micro-manipulation remained relatively the same in 2022 (we received no records from the USA, but recovered data from South Korea). As observed in the past few years and consistent with the current trends of the world embryo industry, most of the embryos micro-manipulated were IVP (95.0% of sexed and 95.1% of genotyped). Canada also reported that 150 IVD embryos were split before transfer.

Table 9. Micromanipulation of bovine embryos for sexing and/or genotyping in 2022

Country	Sexed		Genotyped	
	IVD	IVP	IVD	IVP
Canada	42	8,907	0	8,907
France	266	0	678	88
Germany	163	9	0	0
Netherlands	0	0	0	4156
South Korea	0	0	0	73
United States	0	0	0	0
Total	471	8,916	678	13,224

4.1.3 Other species

The numbers of IVD and IVP embryos reported in 2022 in species other than cattle are shown in Tables 10 (sheep), 11 (goats), 12 (horses) and 13 (camelids, cervids and buffaloes). Sheep and horses had the greatest number of embryos collected or produced (43,174 and 38,490, respectively) reported by numerous countries (13 for each). In sheep, both the number of IVD and IVP embryos increased compared with last year (+3.1% and +12.5%, respectively). We observed a decrease in the number of IVD embryos actually transferred (-39.0%). This reduction, however, was associated with an inconsistency between the number of IVD embryos collected and transferred reported in 2021 (41,183 vs 66,840, respectively), driven mainly by the numbers from one country (UK) and, thus, may not represent a true tendency. Most of the IVD sheep embryos were transferred fresh (94.3%), whereas most of the IVP were transferred frozen-thawed (83.2%). As observed last year, Australia was the leader in collections and transfers of IVD sheep embryos (52.4% and 51.7% of world totals, respectively). Australia also recorded most of the sheep IVP embryos (69.0%), but the USA accounted for all IVP embryos actually transferred in 2022.

Table 10. Sheep: *in vivo* derived [IVD] and *in vitro* produced [IVP] embryo collections and transfers in 2022

Region/ Country	IVD Embryos						IVP embryos					
	Flushes	Embryos	Embryo transfer				Donors	Oocytes	Embryo transfer			
			Fresh	Frozen		Fresh			Frozen			
				Domestic	Foreign				Domestic	Foreign		
Europe												
Hungary	7	7	7	0	0	0	0	0	0	0	0	
Portugal	12	16	7	0	0	0	0	0	0	0	0	
Serbia	0	0	0	0	0	2	22	6	0	0	0	
Sweden	0	0	0	0	0	0	0	0	0	0	295	
Turkey	5	13	7	6	96	0	0	0	0	0	0	
UK	290	1,296	1,095	175	0	12	48	0	0	0	0	
Total	314	1,332	1,116	181	96	14	70	6	0	0	295	
N America												
Canada	81	180	143	64	56	0	0	0	0	0	0	
Mexico	78	422	338	84	0	0	0	0	0	0	0	
USA	1,990	11,322	10,484	551	0	228	1,777	176	89	145	0	
Total	2,149	11,924	10,965	699	56	228	1,777	176	89	145	0	
Oceania												
Australia	3,142	22,255	20,333	743	5	3	566	486	0	0	0	
Total	3,142	22,255	20,333	743	5	3	566	486	0	0	0	
S America												
Brazil	847	6,875	6,021	488	0	0	0	0	0	0	0	
Panama	0	0	0	0	0	2	120	36	0	0	0	
Peru	15	84	30	54	0	0	0	0	0	0	0	
Total	862	6,959	6,051	542	0	2	120	36	0	0	0	
Grand Total	6,467	42,470	38,465	2,165	157	247	2,533	704	89	145	295	

The embryo industry in goats has been headed by the USA, which accounted for 85.1% and 100.0% of all IVD and IVP embryos, respectively, in 2022. Therefore, the global trends in this species (a 53.4% increase in IVD and -66.2% decrease in IVP) were most affected by the American numbers. Australia, the second country in the goat embryo industry, reported no IVP

embryo in 2021, but 150 IVP embryos in 2022. On the other hand, Spain reported 648 IVD embryos in 2021, but none in 2022.

Table 11. Goats: *in vivo* derived [IVD] and *in vitro* produced [IVP] embryo collections and transfers in 2022

Region/ Country	IVD Embryos					IVP embryos					
	Flushes	Embryos	Embryo transfer			Donors	Oocytes	Embryos	Embryo transfer		
			Fresh	Frozen					Fresh	Frozen	
				Domestic	Foreign					Domestic	Foreign
Europe											
Türkiye	2	24	24	0	0	0	0	0	0	0	0
UK	1	22	22	0	16	0	0	0	0	0	0
Total	3	46	46	0	16	0	0	0	0	0	0
N America											
Mexico	43	266	214	52	0	0	0	0	0	0	0
USA	1,896	14,605	13,027	985	0	320	6,605	2,147	1,146	602	0
Total	1,939	14,871	13,241	1,037	0	320	6,605	2,147	1,146	602	0
Oceania											
Australia	231	2,051	1,535	111	32	1	198	150	0	0	0
Total	231	2,051	1,535	111	32	0	0	0	0	0	0
S America											
Brazil	19	199	141	327	0	0	0	0	0	0	0
Total	19	199	141	327	0	0	0	0	0	0	0
Grand Total	2,192	17,167	14,963	1,475	48	320	6,605	2,147	1,146	602	0

In horses, contrasting trends were observed according to the technology used, as observed in 2021. Both the number of IVD embryos collected and transferred decreased (−4.8% and −12.2%, respectively), whereas numbers of IVP embryos increased (+22.6% and +232.7%, respectively). If the current trends continue, it is possible that the number of IVP embryos pass those of IVD in the near future, becoming the technique of choice for embryo production in horses, as occurred for cattle in the last decade. Brazil and Italy lead the number of IVD and IVP horse embryos, with 93.1% and 49.4.2% of world totals, respectively. In the former, however, all embryos were for the domestic market, whereas in the latter most IVP embryos (51.3%) were exported.

Table 12. Horses: *in vivo* derived [IVD] and *in vitro* produced [IVP] embryo collections and transfers in 2022

Region/ Country	IVD Embryos					IVP embryos					
	Embryo transfer					Embryo transfer					
	Flushes	Embryos	Fresh	Frozen		Donors	Oocytes	Embryos	Fresh	Frozen	
				Domestic	Foreign					Domestic	Foreign
Europe											
Czech Rep	23	22	7	0	0	0	0	0	0	0	0
Hungary	3	3	3	0	0	0	0	0	0	0	0
Italy	0	0	0	0	0	1,595	47,321	7,036	9	796	0
Poland	7	7	7	7	0	21	210	21	0	0	0
Portugal	87	49	49	0	0	39	419	74	0	0	2
Romania	3	0	2	0	0	0	0	0	0	0	0
Russian Fed.	42	28	25	2	0	0	0	0	0	0	0
Sweden	33	0	23	0	0	0	0	0	23	0	0
Switzerland	0	0	0	0	0	40	114	22	0	14	8
Total	198	109	116	9	0	1,695	48,064	7,153	32	810	10
N America											
Mexico	14	12	6	0	0	0	0	0	0	0	0
USA	1672	976	904	40	0	1676	14,081	2,979	517	498	0
Total	1,686	988	910	40	0	1,676	14,081	2,979	517	498	0
S America											
Brazil	39,680	22,569	21,380	0	0	0	20,550	4,110	2,100	2,010	0
Colombia	1,184	582	564	0	0	0	0	0	0	0	0
Total	40,864	23,151	21,944	0	0	0	20,550	4,110	2,100	2,010	0
Grand Total	42,748	24,248	22,970	49	0	3,371	82,695	14,242	2,649	3,318	10

In 2022, embryo activity was also reported in cervids, buffalo, camelids, and swine (Table 13). It is noteworthy that most embryos reported in cervids were IVP (98.2%), whereas most buffalo embryos (86.8%) and all camelids and swine embryos (100.0%) were IVD. Data from camelids were reported only from Peru and included 30 embryos collected from Llamas and 55 from alpacas.

Table 13. Other species: *in vivo* derived [IVD] and *in vitro* produced [IVP] embryo collections and transfers in 2022

Region/ Country	IVD Embryos					IVP embryos					
	Embryo transfer					Embryo transfer					
	Flushes	Embryos	Fresh	Frozen		Donors	Oocytes	Embryos	Fresh	Frozen	
				Domestic	Foreign					Domestic	Foreign
Cervids											
Hungary	0	0	0	0	0	24	1,732	204	0	0	0
Mexico	0	0	0	0	0	12	75	18	0	0	0
United States	17	4	4	0	0	0	0	0	0	0	0
Total	17	4	4	0	0	36	1,807	222	0	0	0
Buffalo											
Türkiye	59	46	40	0	0	0	0	0	0	0	0
Ecuador	0	0	0	0	0	4	43	7	0	0	0
Total	59	46	40	0	0	4	43	7	0	0	0

Camelids											
Peru (Llamas)	18	30	8	22	0	0	0	0	0	0	0
Peru (Alpacas)	30	55	16	39	0	0	0	0	0	0	0
Total	48	85	24	61	0	0	0	0	0	0	0
Other											
Hungary (swine)	12	214	0	0	0	0	0	0	0	0	0
Romania	31	209	0	0	0	0	0	0	0	0	0
Total	43	423	0	0	0	0	0	0	0	0	0
Grand Total	167	558	68	61	0	40	1,850	229	0	0	0

4.1.4 Exports

Table 14. Countries exporting embryos in 2022
Bovine

Region/ Country	IVD		IVP		Sheep IVD	Goats IVD	Horse IVP
	Dairy	Beef	OPU	Abattoir			
Europe							
Austria	24	0	0	0	0	0	0
Denmark	18	9	0	0	0	0	0
Finland	573	0	281	0	0	0	0
France	124	256	0	0	0	0	0
Germany	853	0	0	0	0	0	0
Italy	0	0	0	0	0	0	3,609
Poland	0	0	0	0	0	0	21
Spain	31	0	29	0	0	0	0
Switzerland	152	0	0	0	0	0	8
United Kingdom	4	135	130	0	0	0	0
Total	1,779	400	440	0	0	0	3,638
N America							
Canada	2,582	3,613	1,868	0	0	0	0
United States	27,685	3,918	4,622	0	0	0	0
Total	30,267	7,531	6,490	0	0	0	0
Oceania							
Australia	33	2,736	0	0	347	329	0
Total	33	2,736	0	0	347	329	0
S America							
Colombia	0	0	290	0	0	0	0
Total	0	0	290	0	0	0	0
Grand Total	32,079	10,667	7,220	0	347	329	3,638

The numbers of embryo exports by species, technique and country are shown in Table 14. Less countries reported the export of embryos in 2022 (13 vs 17 in 2021). Nevertheless, the total embryos exported increased in 2022 compared with 2021 (54,280 vs 46,239, +17.4%). In cattle, the number of IVD embryos exported in 2022 increased substantially in dairy breeds (+65.0%) and resulted in an overall increase of 38.2% relative to 2021 (42,746 vs 30,918), despite the decrease observed in beef breeds (-7.1%). The number of IVP cattle embryos exported in 2022 decreased by -30.7%, particularly due to the scenario in Europe and South America. No export of embryos produced with abattoir ovaries was recorded.

Only Australia reported export of IVD sheep embryos and, therefore, these numbers decreased compared with 2021 (347 vs 1,199). Australia also reported export of 200 IVD goat embryos. Horse IVP embryos were exported only by European countries, with numbers increasing +3.9% compared with 2021. Italy accounted for 99.2% of these embryos.

4.2 Historical series and trends

The historical series are of special interest because they depict the medium- to long-term trends of the world embryo industry, avoiding misinterpretations due to occasional fluctuations observed from one year to the next. The series of cattle embryo production (IVD, IVP, and total) in the past 20 years (2003 to 2022) is shown in Figure 2. The number of IVP

embryos has been increasing continuously since 2012, driving the trend towards the increase in totals during this period (+76.0%). On the other hand, the number of IVD embryos had decreased from 2015 to 2020 (-45.2%) and been slightly increasing since then (+9.1%). The balance between the rate of increase in IVP versus decrease in IVD numbers led to the fluctuations observed in the totals during this period, with reductions observed in two periods (2013 to 2014 and 2018 to 2019). In this regard, the current trends of increase in the records of both IVP and IVD embryos highlights that the increase in the IVP numbers, particularly in the past two years, cannot be explained by the shift towards *in vitro* technologies. In fact, the expansion in the use of ET, likely associated with emerging market niches, is what is leading to the increase in total numbers.

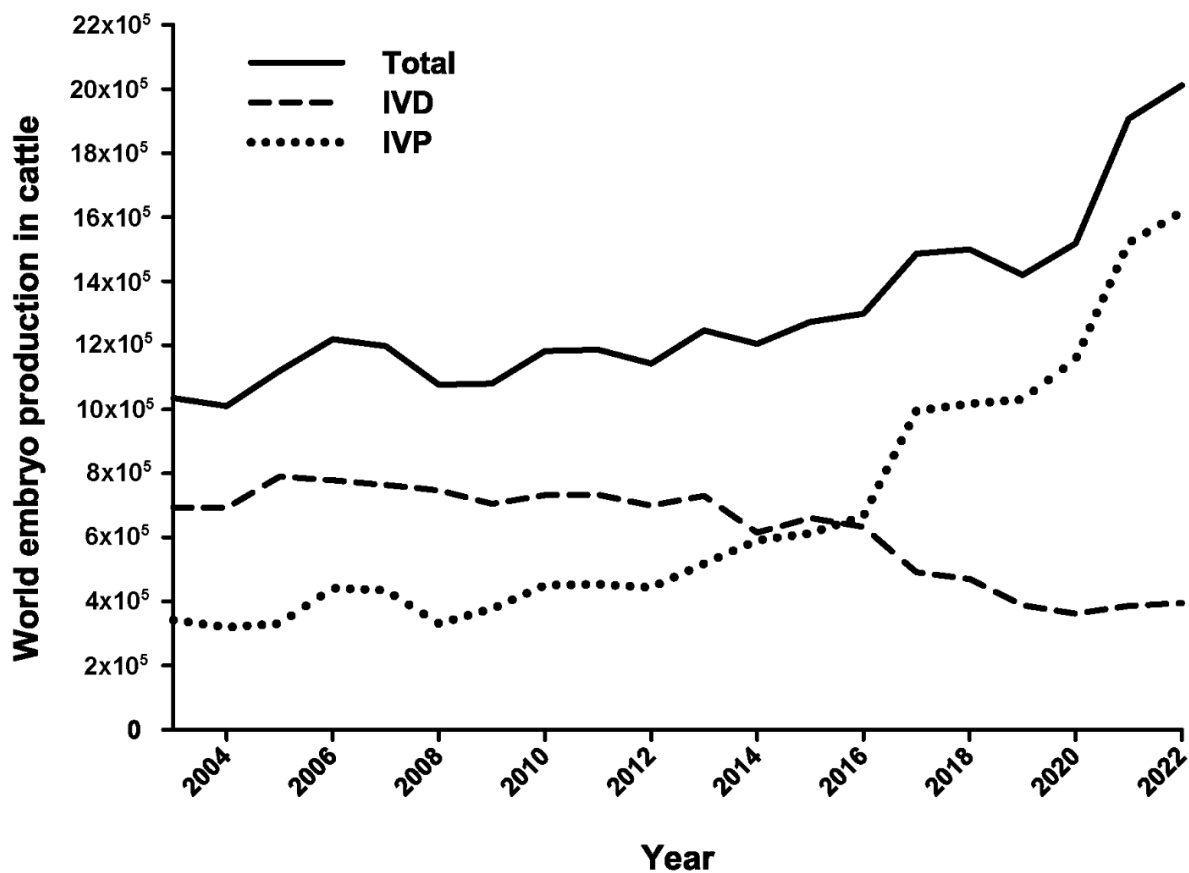


Figure 2. Number of bovine embryos (*in vivo* derived [IVD], *in vitro* produced [IVP], and total) recorded in the period 2003-2022.

The numbers of IVP and IVD embryos recorded per region are shown in Figures 3A and 3B, respectively. The use of IVP embryos in North and South America diverged in 2022 (+10.1% vs -0.4%, respectively), after presenting similar trends during five years (2016–2021). Yet, these regions still account for most of the IVP embryos produced worldwide. Conversely, the number of IVD embryos had a similar trend of increase since 2020 in Europe (+8.3%), North America (+4.1%), and South America (+15.8%), resulting in the rebound observed in IVD totals.

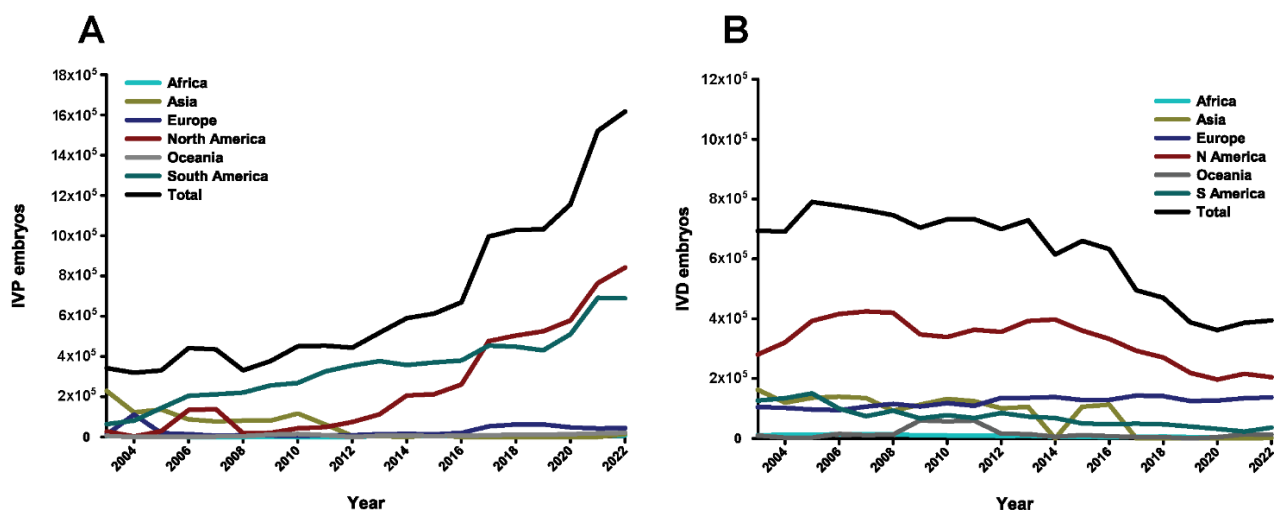


Figure 3. Number of embryos produced or collected in cattle in the period of 2003–2022, by continent. (A) *In vitro* produced (IVP) embryos; (B) *In vivo* derived (IVD) embryos.

The number and the percent share of frozen-thawed IVD and IVP embryos transferred from 2003 to 2022 are shown in Figures 4A and 4B. The proportion of IVP embryos transferred (fresh + frozen) decreased for the first time since 2015, due to the recent increase in the number of IVD embryo transfers (+17.5% in 2022). Nevertheless, both the proportion of IVD and IVP frozen embryos increased since 2020 and the total of embryos (IVP+IVD) transferred after cryopreservation reached 49.1%, the greatest value for the period 2003–2022.

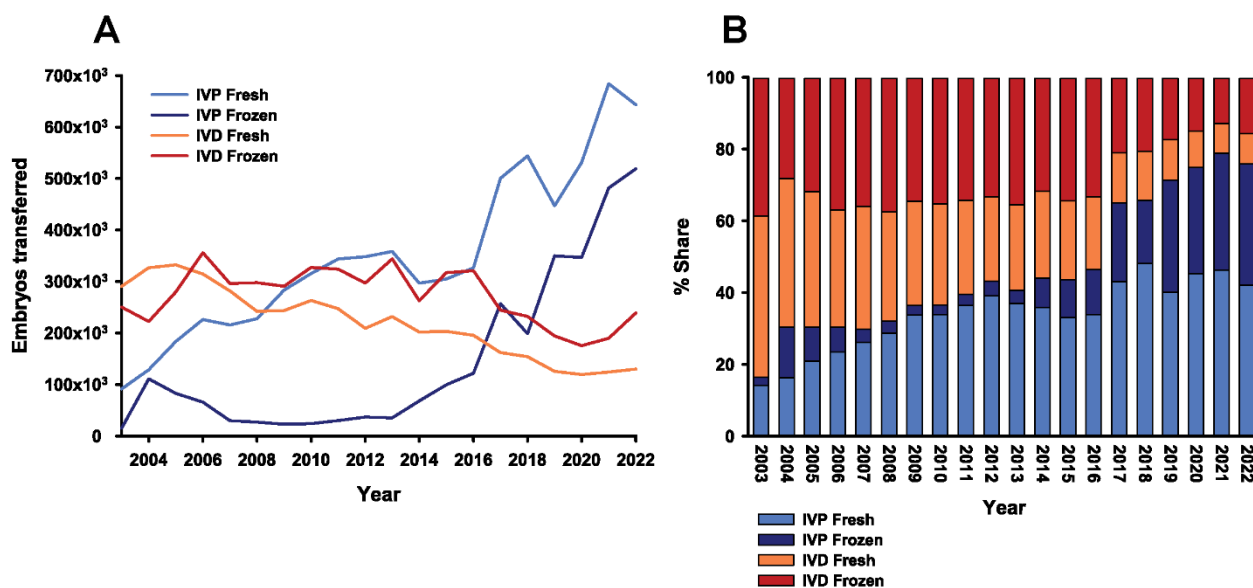


Figure 4. Embryo transfers in cattle in the period of 2003–2022, according to the technique used (*in vivo* derived [IVD] or *in vitro* produced [IVP]) and type of embryo (fresh or frozen-thawed). (A) Number of embryos transferred. (B) Percent share of the total embryo transfers per year.

4.3 Embryo industry rank

The embryo index was proposed in our last report to create a reference for the intensity of the use of embryo technologies by different countries, taking into account the size of the cattle herds in each country. In 2022, the top 5 countries in the intensity rank did not change relative to 2021. The index from the leader USA, however, increased from 85.5 in 2021 to 96.2

in 2022, reflecting the increase in total embryo production in this country. In contrast, the index decreased from 83.7 to 73.5 in the Netherlands, the second in rank. Minor changes were observed within the top 20 countries in this rank (Table 15), caused mainly by the inclusion of data from South Korea and by the lack of data from Costa Rica in 2022.

The difference between total embryo production and the intensity of technology use is depicted as density maps in Figure 5A and 5B.

Table 15. Top 20 countries according to the ET intensity index in 2022. This index considers the ratio between the number of embryos recorded by each country and the size of the cattle herd in each country.

Country	Embryos ¹	Embryo rank	Cattle herd ²	Herd rank ³	Index ⁴	Intensity rank
USA	901,815	1	93,789,500	3	96.2	1
Netherlands	27,217	11	3,705,000	63	73.5	2
Canada	70,934	6	11,057,929	30	64.1	3
Panama	7,160	18	1,509,900	97	47.4	4
Finland	3,638	24	829,980	111	43.8	5
South Korea	14,098	13	3,990,257	60	35.3	6
Germany	36,513	9	11,039,660	31	33.1	7
Italy	20,722	12	6,280,280	45	33.0	8
Denmark	4,738	21	1,480,000	99	32.0	9
Paraguay	44,297	7	13,919,507	24	31.8	10
Colombia	82,339	4	29,301,392	12	28.1	11
Norway	2,365	30	901,026	108	26.2	12
Switzerland	3,828	22	1,513,872	96	25.3	13
France	38,806	8	17,330,080	20	22.4	14
Brazil	464,417	2	224,602,112	1	20.7	15
Mexico	73,997	5	35,998,615	8	20.6	16
Argentina	105,766	3	53,416,435	6	19.8	17
Hungary	1,801	33	909,900	107	19.8	18
Austria	3,673	23	1,870,100	87	19.6	19
Ecuador	7,683	17	4,066,930	59	18.9	20

¹Total of embryos (IVD + IVP) recorded in 2022.

²According to FaoStat 2021 [1].

³According to cattle herd size, ranked from the largest to the smallest.

⁴Embryos recorded per 10,000 cattle heads.

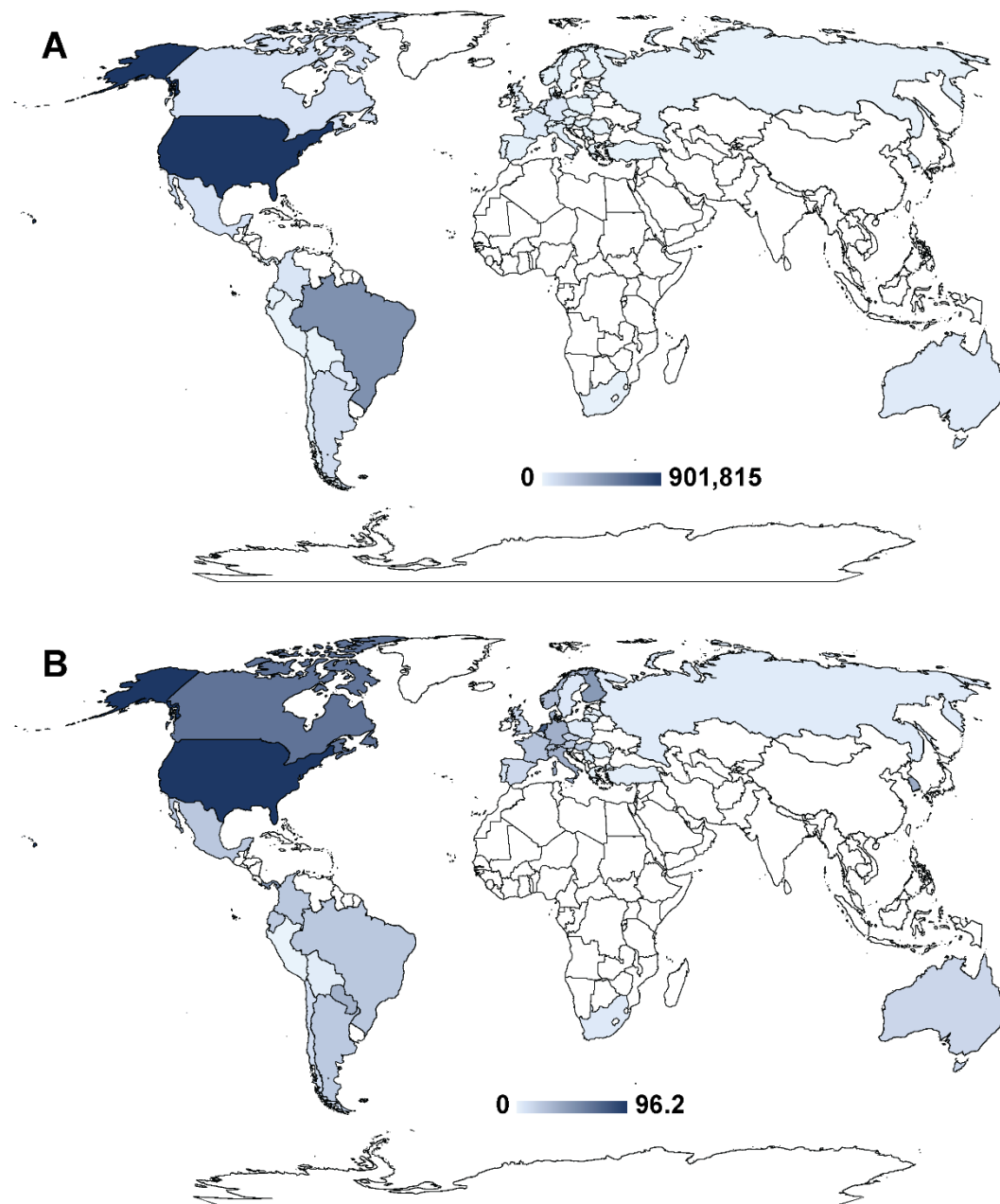


Figure 5. World density map depicting (A) total bovine embryo production, and (B) number of embryos per 10,000 cattle heads in each country in 2022. Image generated using Microsoft Excel.

5. Discussion

The general scenario of the world embryo industry in 2022 was of consolidation of the main trends observed in the past decade. The rate of growth observed in the total cattle embryo records, as well as in sheep and horses, was lesser than the steep rise observed in 2021, when the demand for ET services was stimulated by the rise on the animal protein international prices as previously discussed^[2]. The current growth rate, however, is consistent with the long-term trends of the embryo industry. The number of embryos recorded in cattle in 2022, for example, increased +5.5%, a rate similar to the average observed in the past 10 years (circa +6.1%). Moreover, albeit the embryo industry in 2022 was less affected by the short-term consequences of the pandemic, such as shutdowns or disturbs on the logistics and supply chains^[3], in many countries the scenario was still of economic and political instability, boosted by the geopolitical consequences of the conflict between Ukraine and Russia.

In this regard, if the increase in the number of embryos collected *in vivo* observed in 2021 could be explained by the positive moment of the cattle embryo industry, when the number of IVP embryos increased remarkable +31.5%, the situation was quite different in 2022. Although the general trend was still positive, the scenario was similar to the one observed in 2020, when IVD numbers actually decreased (-6.7%), despite an overall increase of +7.0%. In fact, *in vitro* technologies have been replacing superovulation as the technique of choice for cattle embryo production and, in 2022, seven out of the top 10 countries in the embryo rank recorded more IVP than IVD embryos (EUA, Brazil, Argentina, Colombia, Mexico, Paraguay, and Australia). The increase in IVD numbers since 2020 suggests, therefore, a resilience of the market niche for superovulation, even in countries with consolidated adoption of IVP, such as Brazil.

Other main trends of the word embryo industry remained unchanged. The Americas accounted for most of the ET activity with the USA leading records of embryo production, whereas Brazil leads embryo transfers. Moreover, only minor changes occurred in the top 20 countries in the embryo intensity rank (which was proposed to take into account the proportion between embryo production and cattle herd size). A growing number of countries is adopting IVP, with reflections not only on the total embryos produced, but also on the proportion of IVP embryos micromanipulated, cryopreserved, or produced from species other than cattle, such as sheep and horses. The use of FSH stimulation prior to OPU is more frequent in dairy cattle and in countries from Europe and North America. The production of IVP embryos using abattoir ovaries remain not significant.

An interesting feature of the 2022 data is the apparent inconsistency between the number of IVP embryos produced and actually transferred, particularly evident in Europe and North America. This difference probably reflects the changes in the world embryo industry subsequent to the adoption of *in vitro* technologies. In most cases, IVD embryos are collected and transferred by the same practitioner or ET team. Conversely, it is not unusual to observe a stratification of the procedures involved in IVP embryo production and transfer, with different steps of the process being carried out by different teams. In addition, many IVP companies choose to produce a surplus of embryos, either to guarantee that all suitable synchronized recipients will actually receive an embryo if transfer is of fresh embryos; or to increase the selection pressure of the embryos to be frozen. If data is reported by the IVP laboratory, totals may, therefore, reflect overall embryo production, regardless of the fate of the embryos, creating such differences. This situation brings an additional challenge for the data retrieval committee and analysis process. Nonetheless, the IVP market is less scattered than that of IVD embryos, making data collection easier and less likely to underestimate the actual numbers.

6. Acknowledgements

The Data Retrieval Committee thank the efforts of all regional data collectors, as well as all practitioners or representatives of ET companies who reported data to the database or directly to the chair. The comprehensiveness of the present report is the result of the volunteer collaboration of all these colleagues. The chair also thanks Dr. Luiz G. Siqueira for reviewing this report.

7. References

[1] <https://www.fao.org/faostat/en/#data/QCL>

[2] Viana JHM. 2021 Statistics of embryo production and transfer in domestic farm animals: A new milestone has been reached: transfers of IVP embryos were over one million worldwide. Embryo Technology Newsletter, v. 40, n.4, p. 22-40, 2022.

[3] Viana JHM, Demetrio D. The impact of the Covid-19 pandemic on the embryo industry: the practitioners' perspective. Embryo Technology Newsletter, v. 39, n.4, p. 39-43, 2021.

Appendix 1: National data collectors in 2022

Region/Country	Collector	Region/Country	Collector
Africa		Europe	
Rep South Africa	Morne de la Rey	AETE	Hélène Quinton
Asia		Austria	Friedrich Führer
Korea	Junkoo Yi, Daehyun Kim	Belgium	Peter Vercauteren, Isabelle Donnay
Vietnam	Joao Viana*, ABS	Denmark	Henrik Callesen
Oceania		Finland	Seija Vahtiala
Australia	Corrie Croton, DAFF	France	Serge Lacaze
North America		Germany	Hubert Cramer
Canada	Reuben Mapletoft (CETA)	Greece	Foteini Samartzi
Mexico	Salvador Romo, ABS	Ireland	Patrick Lonergan
United States	Charles Looney, Alvaro Garcia-Guerra, Scott Larsen (AETA)	Italy	Giovanna Lazzari
South & Central America		Latvia	Vita Antane
Argentina (bovine)	Gabriel Bo (SATE)	Lithuania	Raisa Nainiene
Brazil (bovine)	Joao Viana (SBTE)	The Netherlands	Helga Flapper, Hilde Aardema
Brazil (equine)	Marco Alvarenga	Norway	Marja Mikkola
Brazil (small rum)	Joanna Souza-Fabjan	Portugal	João Nestor Chagas e Silva
Bolivia	Joao Viana*, ABS	Romania	Stefan Ciornei
Colombia	Jorge Luis Zambrano, ABS	Russian Federation	Denis Knurow, Viktor Madison, ABS
Ecuador	Andres Vera Cedeño	Serbia	Aleksandar Milovanovic
Panama	Luis Nasser	Slovenia	Janko Mrkun
Paraguay	María Paz Benítez Mora, Gabriel Soria	Spain	Daniel Martinez Bello, CETA
Peru	Marlene Miguel-Gonzales, Edwin Mellisho	Sweden	Renée Båge
Uruguay	Joao Viana*, ABS	Switzerland	Rainer Saner
Venezuela	Joao Viana*, ABS	United Kingdom	Roger Sturmey, Brian Graham, CETA

*Data collected/organized by the Chair

Appendix 2. Collection of bovine *in vivo*-derived (IVD) embryos by region and country in 2022

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												
Rep. South Africa	0	271	271	0	0	0	0	3,382	3,382	0	2,027	2,027
Asia												
South Korea	0	301	301	0	2	2	0	2,293	2,293	0	1,764	1,764
Europe												
Austria	484	12	496	42	1	43	5,048	174	5,222	3,595	40	3,635
Belgium	13	652	665	0	0	0	78	3,677	3,755	22	2,407	2,429
Czech Rep	410	0	410	0	0	0	2,939	0	2,939	2,043	0	2,043
Denmark	773	50	823	0	0	0	6,170	535	6,705	4,336	402	4,738
Finland	338	2	340	27	0	27	3,492	16	3,508	2,553	10	2,563
France	4,070	1,413	5,483	766	73	839	40,105	15,160	55,265	25,092	8,450	33,542
Germany	3,970	340	4,310	0	0	0	37,465	4,048	41,513	25,826	2,364	28,190
Greece	0	0	0	4	0	4	23	0	23	14	0	14
Hungary	9	25	34	380	13	393	1,780	225	2,005	1,573	181	1,754
Italy	950	112	1,062	1,195	0	1,195	21,085	1,098	22,183	19,410	796	20,206
Lithuania	2	0	2	0	0	0	5	0	5	5	0	5
Netherlands	2,436	0	2,436	30	0	30	19,762	0	19,762	12,879	0	12,879
Norway	365	10	375	5	0	5	2,436	93	2,529	2,230	65	2,295
Poland	112	3	115	123	0	123	2,034	29	2,063	1,322	16	1,338
Portugal	11	30	41	74	0	74	781	302	1,083	364	160	524
Romania	11	4	15	0	0	0	68	3	71	31	3	34
Russian Fed.	162	747	909	196	6	202	1,840	7,259	9,099	867	4,545	5,412
Slovenia	12	2	14	3	0	3	60	7	67	21	7	28
Spain	25	104	129	154	8	162	1,721	1,241	2,962	782	757	1,539
Sweden	114	0	114	9	0	9	971	0	971	655	0	655
Switzerland	189	1	190	219	2	221	4,664	69	4,733	2,876	34	2,910
Turkey	139	0	139	176	0	176	2,824	0	2,824	1,791	0	1,791
United Kingdom	748	3,296	4,044	0	0	0	7,431	9,516	16,947	4,138	4,374	8,512
North America												
Canada	1,674	2,953	4,627	2,409	25	2,434	41,116	36,597	77,713	23,097	20,584	43,681
Mexico	0	685	685	0	80	80	0	5,850	5,850	0	4,870	4,870
United States	3,321	14,713	18,034	4,978	2,005	6,983	61,835	192,322	254,157	44,182	111,949	156,131
Oceania												
Australia	98	2610	2,708	90	23	113	1574	7450	9,024	686	11769	12,455
South America												
Argentina	183	2,544	2,727	105	1	106	3,604	28,403	32,007	1,802	13,811	15,613
Brazil	2,816	1,655	4,471	0	0	0	14,083	6,622	20,705	14,083	6,622	20,705
Colombia	15	8	23	18	5	23	231	90	321	161	66	227

Appendix 3. Transfer of bovine *in vivo* derived (IVD) embryos by region and country in 2022

Region/ Country	Dairy	Fresh embryos			Dairy	Frozen domestic embryos			Dairy	Frozen imported embryos		
		Beef	Unsorted	Total		Beef	Unsorted	Total		Beef	Unsorted	Total
Africa												
Rep. South Africa	0	1,453	0	1,453	0	1,566	0	1,566	0	45	0	45
Asia												
South Korea	0	470	0	470	0	819	0	819	0	52	0	52
Europe												
Austria	1,515	16	0	1,531	1,786	94	0	1,880	48	0	0	48
Belgium	2	493	0	495	20	1,914	0	1,934	0	0	0	0
Czech Rep	1,253	0	0	1,253	914	0	0	914	0	0	0	0
Denmark	3,147	103	0	3,250	1,519	106	0	1,625	0	0	0	0
Finland	722	3	0	725	1,875	12	0	1,887	83	50	0	133
France	12,031	2,863	0	14,894	10,525	3,375	0	13,900	877	156	0	1,033
Germany	10,861	836	0	11,697	15,403	1,340	0	16,743	0	0	0	0
Greece	14	0	0	14	0	0	0	0	7	0	0	7
Hungary	644	62	0	706	621	83	0	704	0	13	0	13
Italy	6,037	132	0	6,169	1,755	0	0	1,755	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	2,290	0	0	2,290	9,596	0	0	9,596	0	0	0	0
Norway	43	30	0	73	2,063	35	0	2,098	150	80	0	230
Poland	783	4	0	787	286	0	0	286	46	0	0	46
Portugal	124	74	0	198	170	53	0	223	0	88	0	88
Romania	61	4	0	65	0	0	0	0	0	46	0	46
Russian Fed.	312	10	0	322	587	4,586	0	5,173	1,045	121	0	1,166
Slovenia	30	3	0	33	5	4	0	9	0	0	0	0
Spain	353	132	0	485	478	322	0	800	61	100	0	161
Sweden	0	0	420	420	0	0	1,099	1,099	0	0	0	0
Switzerland	671	0	0	671	1,952	0	0	1,952	270	0	0	270
Turkey	1,128	0	0	1,128	113	0	0	113	0	0	0	0
United Kingdom	1,738	795	0	2,533	2,097	2,240	0	4,337	814	438	0	1,252
North America												
Canada	7,331	3,511	0	10,842	8,695	11,448	0	20,143	265	631	0	896
Mexico	0	3,409	0	3,409	0	1,461	0	1,461	0	0	0	0
United States	11,463	28,300	0	39,763	32,719	83,649	0	116,368	0	0	0	0
Oceania												
Australia	260	2,600	0	2,860	363	5,339	0	5,702	33	212	0	245
South America												
Argentina	1,081	5,045	0	6,126	295	7,430	0	7,725	42	15	0	57
Brazil	11,482	3,822	0	15,304	9,030	3,187	0	12,217	0	0	0	0

Appendix 4: Production of bovine embryos <i>in vitro</i> (IVP) with OPU-collected oocytes by region and country in 2022															
Region/ Country	Donor preparation					Oocytes					Transferrable embryos				
	Non-stimulated		Stimulated		Total	Non-stimulated		Stimulated		Total	Non-stimulated		Stimulated		Total
	Dairy	Beef	Dairy	Beef		Dairy	Beef	Dairy	Beef		Dairy	Beef	Dairy	Beef	
Africa															
Rep. South Africa	0	1,575	0	0	1,575	0	26,334	0	0	26,334	0	7,377	0	0	7,377
Asia															
South Korea	86	2,188	0	246	2,520	1,207	25,636	0	3,188	30,031	382	7,816	0	792	8,990
Vietnam	1,246	0	0	0	1,246	13,313	0	0	0	13,313	2,399	0	0	0	2,399
Europe															
Austria	0	0	25	0	25	0	0	237	0	237	0	0	38	0	38
Finland	521	0	0	0	521	4,749	0	0	0	4,749	1,075	0	0	0	1,075
France	0	0	1,544	38	1,582	0	0	19,448	924	20,372	0	0	4,872	392	5,264
Germany	0	0	2,506	144	2,650	0	0	29,701	2,337	32,038	0	0	7,858	465	8,323
Hungary	1	1	0	0	2	6	4	0	0	10	1	1	0	0	2
Italy	0	0	177	28	205	0	0	1,798	114	1,912	0	0	488	28	516
Netherlands	0	0	5,871	0	5,871	0	0	62,410	0	62,410	0	0	11,773	0	11,773
Norway	39	0	0	0	39	447	0	0	0	447	70	0	0	0	70
Poland	0	0	150	0	150	0	0	2,242	0	2,242	0	0	553	0	553
Romania	40	0	0	0	40	209	0	0	0	209	84	0	0	0	84
Russian Federation	97	0	0	0	97	985	0	0	0	985	147	0	0	0	147
Serbia	32	0	0	0	32	412	0	0	0	412	141	0	0	0	141
Spain	453	85	295	111	944	3,601	623	4,287	1,716	10,227	1,293	323	1,023	442	3,081
Switzerland	0	0	228	0	228	0	0	2,414	0	2,414	0	0	918	0	918
Turkey	0	0	144	0	144	0	0	1,843	0	1,843	0	0	239	0	239
United Kingdom	327	0	460	0	787	4,920	0	7,376	0	12,296	1,408	0	2,459	0	3,867
North America															
Canada	3	0	3,353	1,551	4,907	0	0	38,523	21,956	60,479	0	0	17,808	9,059	26,867
Mexico	705	8,980	0	80	9,765	11,885	230,713	0	2,790	245,388	3,310	64,272	0	682	68,264
United States	27,072	18,351	72,092	46,495	164,010	528,359	470,862	1,407,023	1,192,960	3,599,204	90,979	116,717	242,277	295,711	745,684
Oceania															
Australia	42	4,656	121	87	4,906	203	95,684	361	478	96,726	58	20,289	109	175	20,631
South America															
Argentina	0	16,901	29	152	17,082	0	359,594	276	2,653	362,523	0	89,415	101	637	90,153
Bolivia	0	440	0	0	440	0	9,316	0	0	9,316	0	2,965	0	0	2,965
Brazil	70,200	22,685	0	0	92,885	842,403	453,693	0	0	1,296,096	252,721	181,477	0	0	434,198
Chile	1,166	500	0	0	1,666	10,410	4,461	0	0	14,871	2,128	912	0	0	3,040
Colombia	7,733	4,164	0	4,316	16,213	156,671	84,362	0	90,614	331,647	39,088	21,048	0	21,976	82,112
Ecuador	1,867	480	0	0	2,347	27,650	9,198	0	0	36,848	5,697	1,986	0	0	7,683
Panama	152	957	0	0	1,109	2,280	17,629	0	0	19,909	456	6,704	0	0	7,160
Paraguay	0	7,994	0	0	7,994	0	173,995	0	0	173,995	0	44,297	0	0	44,297
Uruguay	0	2,196	0	0	2,196	0	28,916	0	0	28,916	0	7,149	0	0	7,149
Venezuela	0	62	0	0	62	0	701	0	0	701	0	144	0	0	144

Appendix 5: Production of bovine embryos *in vitro* (IVP) with abattoir-derived oocytes by region and country in 2022

Region/ Country	Batches			Oocytes			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Asia									
South Korea	169	530	699	3,095	7,421	10,516	938	2,406	3,344
Europe									
Hungary	7	12	19	192	151	343	16	29	45
Latvia	2	0	2	75	0	75	27	0	27
Netherlands	164	0	164	26,890	0	26,890	2,565	0	2,565
Portugal	0	0	0	0	6,768	6,768	0	373	373
Serbia	12	0	12	243	0	243	54	0	54
Spain	0	947	947	0	13,173	13,173	0	3,562	3,562
Turkey	229	64	293	2,478	555	3,033	837	195	1,032
North America									
Canada	235	0	235	2,437	0	2,437	386	0	386
Mexico	0	186	186	0	3,617	3,617	0	863	863
Oceania									
Australia	0	1	1	0	4	4	0	2	2
South America									
Brazil	0	1585	1,585	0	31713	31,713	0	9514	9,514

Appendix 6: Transfer and export of bovine *in vitro* produced (IVP) embryos by region and country in 2022

Region/ Country	Embryos transferred				Abattoir			Exported
	Fresh	OPU Frozen		Total	Fresh	Frozen		
		Domestic	Foreign			Total		
Africa								
Rep. South								
Africa	2,135	4,573	0	6,708	0	0	0	0
Asia								
South Korea	4,775	3,298	125	8,198	1,476	1,311	2,787	0
Vietnam	1,314	876	0	2,190	0	0	0	0
Europe								
Austria	0	19	0	19	0	0	0	0
Finland	0	747	0	747	0	0	0	281
France	2,373	2,138	208	4,719	0	0	0	0
Latvia	9	10	80	99	0	0	0	0
Netherlands	3,907	2,228	0	6,135	0	0	0	0
Poland	89	57	0	146	0	0	0	0
Portugal	0	1	78	79	0	0	0	0
Romania	33	51	0	84	0	0	0	0
Russian Fed.	6	80	0	86	0	0	0	0
Serbia	0	3	0	3	0	0	0	0
Spain	845	1,068	30	1,943	1,394	980	2,374	29
Turkey	0	239	0	239	10	61	71	0
United Kingdom	302	843	1		0	0		130
				1,146			0	
North America								
Canada	2,758	7,109	199	10,066	0	0	0	1,868
Mexico	42,331	17,814	0	60,145	548	315	863	0
United States	213,801	194,735	0	408,536	0	0	0	4,622
Oceania								
Australia	14,679	6,804	51	21,534	0	0	0	0
South America								
Argentina	25,375	56,632	50	82,057	0	0	0	0
Bolivia	2,217	377	0	2,594	0	0	0	0
Brazil	273,019	162,660	0	435,679	3,396	1,181	4,577	0
Chile	345	2,322	0	2,667	0	0	0	0
Colombia	51,531	18,347	700	70,578	0	0	0	290
Ecuador	4,178	1,231	1,819	7,228	0	0	0	0
Panama	2,453	1,184	35	3,672	0	0	0	0
Paraguay	5,740	28,697	0	34,437	0	0	0	0
Uruguay	2,656	4,493	0	7,149	0	0	0	0

Venezuela

61

83

0

144

0

0

0

0