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

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1. Executive summary

The International Embryo Technology Society (IETS) Data Retrieval Committee presents the 31st annual report of data collected globally in 2022 on embryo transfer (ET) activities during the year 2021. As highlighted in the last report, in spite of the social and economic consequences of the COVID-19 pandemic, which was still a major global health issue in 2021, the general trends of the embryo industry were very positive around the world.

Minor changes have been observed in the number of countries reporting ET data in 2021, which remained approximately 20% (40 of 195, 20.5%; Table 1). This stability reflects the consistency in data retrieval from countries within the Americas and Europe, but also the lack of more comprehensive information gathered from African and Asian countries. Nevertheless, we were able to use embryo export data to infer about the activity in other 16 countries that imported embryos but did not submit any data to this committee. These data suggest that embryo technologies are currently in use in 28.7% of the countries worldwide.

The data of the embryo industry in 2021 on the four most representative farm animal species are summarized in Table 2 (total of embryos, produced or collected) and Table 3 (numbers of transferred embryos). Altogether, the numbers depict a very positive moment for the industry, with more than 2 million embryos collected or produced in these species alone. The most remarkable increase occurred in cattle. Over 1.5 million *in vitro*-produced (IVP) embryos were recorded, an increase of 31.5% compared with 2020 (1,521,018 *vs*. 1,156,422, respectively). Interestingly and divergent from the tendency observed since 2015, the number of *in vivo*-derived (IVD) embryos collected and transferred in 2021 has also increased compared with 2020 (+6.8% and +6.5%, respectively); yet in lesser proportions than those observed for IVP embryos. The simultaneous grow in the numbers of IVP and IVD embryos recorded led to an overall increase of 25.6% in the world total cattle embryos, the greatest since 2003. This was a general trend, with all top 10 countries in bovine embryo production in 2020 reporting increased numbers in 2021. Worldwide, IVP embryos accounted for, in 2021, 79.7% of all transferrable cattle embryos.

We observed a similar trend in sheep, with both numbers of IVD and IVP embryos increasing in 2021 compared with 2020 (+38.1% and +344.0%, respectively). On the other hand, the increase in the number of horse embryos recorded in 2021 (+9.6%) was mainly driven by an increase in IVP activity (+34.5%), whereas the number of IVD embryos remained similar to 2020 (25,475 *vs.* 25,219, respectively; +1.0%). In goats, the increase in the number of IVP embryos (+179.3%) was partially compensated by a decrease in the

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

	Cattle		Other (IVD + IVP) [1]				% of Countries
Region	IVD	IVP	Horses	Sheep	Goats	Other [2]	within a region
Africa	0	1	0	0	0	0	1.9 (1/54)
Asia	0	0	0	0	0	0	0.0 (0/48)
Europe	23	13	9	6	2	1	54.5 (24/44)
North America	3	3	3	3	3	2	100.0 (03/03)
Oceania	1	1	0	1	1	0	7.1 (1/14)
South America [3]	4	11	2	1	0	1	34.4 (11/32)
Total	**31**	**29**	**14**	**11**	**6**	**4**	**20.5 (40/195)**

[1]IVD: *in vivo* derived; IVP: *in vitro* produced

[2]Cervids, camelids, buffalo

[3]South and Central America

Table 2. Total production (transferrable embryos) of IVD and IVP embryos in 2021 in cattle, sheep, goats, and horses, by region

	Cattle		Horses		Sheep		Goats	
Region	**IVD**	**IVP**	**IVD**	**IVP**	**IVD**	**IVP**	**IVD**	**IVP**
Africa	0	5,421	0	0	0	0	0	0
Asia	0	0	0	0	0	0	0	0
Europe	134,386	42,410	772	6,775	1,385	180	648	268
North America	215,745	764,650	578	1,347	10,284	446	8,689	6,087
Oceania	13,414	17,681	0	0	21,878	0	1,856	0
South America	22,829	690,856	24,125	3,497	7,636	0	0	0
Total 2021	**386,374**	**1,521,018**	**25,475**	**11,619**	**41,183**	**626**	**11,193**	**6,355**
Total 2020	361,728	1,156,422	25,219	8,641	29,819	141	13,177	2,275
% Change	+6.8	+31.5	+1.0	+34.5	+38.1	+344.0	-15.1	+179.3

number of IVD embryos (−15.1%). Yet, the total number reported in goats increased 13.6% in 2021.

For the first time, over one million IVP cattle embryos were transferred worldwide, a 32.8% increase compared with 2020 (1,166,034 *vs.* 878,181, respectively). Together, IVP and IVD embryos accounted for almost 1.5 million transfers in 2021. The increase in the number of IVP embryos was particularly noticeable in North America (+34.5%) and South America (+37.0%), reflecting the intense activity in countries such as the United States, Mexico, Brazil, and Colombia. In fact, North and South America accounted for 88.1% of all bovine embryos transferred in 2021.

The proportion of frozen-thawed IVP embryos transferred last year was slightly greater than in 2020 (41.3% *vs*. 39.5%, respectively). Although proportionally more frozen-thawed IVD embryos have been transferred compared with their IVP counterparts (60.5% *vs*. 41.3%, respectively), cryopreserved IVP embryos accounted for 32.6% of all transfers in 2021, a greater proportion compared with the 12.8% observed for cryopreserved IVD embryos.

In summary, the already heated market for embryo technologies observed in 2020 was boosted in 2021, resulting in the reach of new milestones of embryos produced and transferred. Although this was a general trend for different species and regions, the increase in embryo activity was particularly evident in cattle and within the Americas.

2. Introduction

The IETS Data Retrieval Committee is the committee in charge of gathering, organizing, and publishing the statistics of the embryo industry in domestic farm animals. This year, we present our 31st annual report showing data on global activities related to *in vivo* and *in vitro* embryo collection and transfer in 2021. The results shown in the present report represents the main trends 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 Data Retrieval Committee 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

Table 3. Transfers of IVD and IVP embryos in 2021 in cattle, sheep, goats, and horses, by region

	Cattle		Horses		Sheep		Goats	
Region	**IVD**	**IVP**	**IVD**	**IVP**	**IVD**	**IVP**	**IVD**	**IVP**
Africa	0	5,382	0	0	0	0	0	0
Asia	0	0	0	0	0	0	0	0
Europe	121,376	21,975	919	843	30,205	0	203	0
North America	161,877	456,978	1,326	1,625	9,027	446	9,552	5,602
Oceania	8,968	17,936	0	0	20,395	0	540	0
South America	21,559	663,763	23,960	3,610	7,213	0	0	0
Total 2021	**313,780**	**1,166,034**	**26,205**	**6,078**	**66,840**	**446**	**10,295**	**5,602**
Total 2020	294,670	878,181	26,241	3,857	32,700	93	12,536	1,381
% Change	+6.5	+32.8	-0.1	+57.6	+104.4	+379.6	-17.9	+305.6

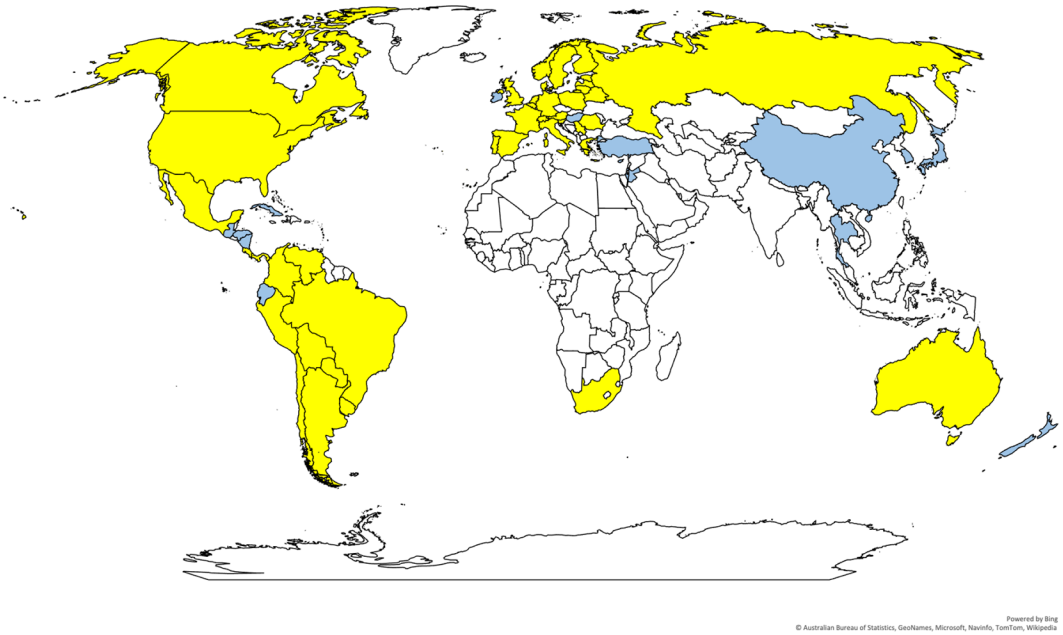

Figure 1. World political map highlighting countries that submitted ET data (yellow) or had records about embryo import (blue) in 2021. Image generated using Microsoft Excel.

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), and 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 were directly uploaded into the IETS website by the national collector or sent to the Chair of the Data Retrieval Committee. 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 2–6), are available as supplemental files at the IETS website (www.iets.org/Committees/Data-Retrieval-Committee).

Table 4. Collection of bovine *in vivo*-derived [IVD] embryos by region in 2021

Region/ Country	Flushes			Collected					
				Ova			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa	0	0	0	0	0	0	0	0	0
Asia	0	0	0	0	0	0	0	0	0
Europe	17,971	4,306	22,277	165,883	42,638	208,521	108,688	25,698	134,386
North America	14,429	22,560	36,989	126,126	247,398	373,524	76,035	139,710	215,745
Oceania	406	2,200	2,606	3,365	9,341	12,706	1,539	11,875	13,414
South America	1,030	3,316	4,346	5,688	24,953	30,641	5,014	17,815	22,829
Total	**33,836**	**32,382**	**66,218**	**301,062**	**324,330**	**625,392**	**191,276**	**195,098**	**386,374**

Table 5. Transfer of bovine *in vivo*-derived [IVD] embryos by region in 2021

Region/ Country	Fresh			Frozen domestic			Frozen imported			Total ET
	Dairy	Beef	Unsorted	Dairy	Beef	Unsorted	Dairy	Beef	Unsorted	
Africa	0	0	0	0	0	0	0	0	0	**0**
Asia	0	0	0	0	0	0	0	0	0	**0**
Europe	44,794	5,604	0	50,297	15,523	0	2,870	2,288	0	**121,376**
North America	22,341	38,943	0	22,839	77,107	0	62	402	183	**161,877**
Oceania	491	1,866	0	611	5,665	0	124	211	0	**8,968**
South America	2,024	7,925	28	2,913	8,135	57	118	273	86	**21,559**
Total	**69,650**	**54,338**	**28**	**76,660**	**106,430**	**57**	**3,174**	**3,174**	**269**	**313,780**

4. Results

Data Retrieval

Only minor changes occurred in the number of countries reporting ET data from the most representative farm species in 2021. In Europe, the only change was that we were able to recover data from Poland (IVD and IVP cattle embryos), but not from Hungary. In Oceania, we did not recover data from New Zealand. In South America, we obtained data from Chile and Costa Rica (IVP cattle embryos) which were absent in 2020. The number of countries reporting cattle IVD embryos remained the same as in 2020 (31), whereas those reporting IVP embryos increased from 26 to 29. In sheep, changes were that Greece, but neither Portugal or Sweden, reported ET activity. In goats, we did not receive data from Brazil. In horses, we now have data from four more countries: Colombia, Portugal, Poland, and Estonia. Once again, in 2021 we were not able to recover any data from Asia. Nonetheless, the Japanese Embryo Transfer Society is working to resume data retrieval and it is likely to report data next year.

Although data collection remains a challenge in Asia and Africa, the overall low variation in the number of countries reporting data has made it easier to track changes in numbers throughout years and, thus, build historical series and provide interpretation of the main trends of the embryo industry worldwide.

As in 2020, data of embryo exports reported by the AETA and by CETA practitioners working abroad provided indirect evidence of ET activity in 16 countries that did not report any data, including six in Asia. In many cases, the low number of embryos imported (a few dozen) suggests an incipient embryo activity. Still, China imported 9,342 bovine embryos from the United States, which is not only a significant amount, but in fact a number of embryos greater than that reported by two-thirds of the countries submitting data to the IETS. Together, countries with direct or indirect ET data account for 48.3% of the world cattle population.[1]

Embryo Industry in Numbers

Cattle, IVD. The number of flushes, ova, and transferrable embryos collected in 2021 by region is shown in Table 4 and the number of transfers is shown in Table 5. A total of 386,374 transferrable IVD embryos were collected, which is 6.8% greater than 2020 (361,728). This is the first increase in the number of IVD embryos since 2015. This increase is likely, however, to reflects the current positive scenario of the embryo industry rather than a change in the trend toward the adoption of *in vitro* technologies. In fact, the increase in the number of IVP embryos reported within the same period was far more significant (31.5%). Among regions, the number of collected IVD embryos in 2021 increased in Europe (+6.2%), North America (+9.7%) and Oceania (+218.5%), but decreased in South America (−27.7%) compared with

Table 6. Production of embryos *in vitro* with OPU-collected oocytes by region in 2021

Region/ Country	Donors			Oocytes			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Africa	0	1,026	1,026	0	19,084	19,084	0	5,421	5,421
Asia	0	0	0	0	0	0	0	0	0
Europe	10,933	934	11,867	118,344	11,526	129,870	29,723	4,301	34,024
North America	91,066	59,015	150,081	1,678,427	1,434,144	3,112,571	352,933	410,160	763,093
Oceania	95	3,934	4,029	477	75,661	76,138	126	17,555	17,681
South America	76,060	54,826	130,886	1,095,138	1,062,117	2,157,255	312,937	365,980	678,917
Total	**178,154**	**119,735**	**297,889**	**2,892,386**	**2,602,532**	**5,494,918**	**695,719**	**803,417**	**1,499,136**

Table 7. Production of embryos *in vitro* with abattoir-derived oocytes by region in 2021

Region/	Donors			Oocytes			Transferrable embryos		
Country	**Dairy**	**Beef**	**Total**	**Dairy**	**Beef**	**Total**	**Dairy**	**Beef**	**Total**
Africa	0	0	0	0	0	0	0	0	0
Asia	0	0	0	0	0	0	0	0	0
Europe	2,522	1,024	3,546	38,812	9,103	47,915	4,712	3,674	8,386
North America	0	105	105	2,095	3,375	5,470	565	992	1,557
Oceania	0	0	0	0	0	0	0	0	0
South America	0	0	0	0	29,847	29,847	0	11,939	11,939
Total	**2,522**	**1,129**	**3,651**	**40,907**	**42,325**	**83,232**	**5,277**	**16,605**	**21,882**

2020. In spite of the increase in absolute numbers, cattle IVD embryos now represents only 20.3% of the total of embryos recorded and 21.2% of the embryos transferred worldwide, in both cases a slight reduction compared with 2020 (it was 23.8% and 25.1%, respectively).

The main features related to the collection and transfer of IVD embryos remained quite unchanged. Europe and North America still account for the majority of IVD embryos collected and transferred (90.6% and 90.3% of the total, respectively, in 2021). We detected a slight decrease in overall superovulation efficiency, with an estimated average of 9.4 ova and 5.8 transferable embryos per flush worldwide. Europe was the only region where IVD embryos were collected predominantly from dairy cows and heifers (80.9%), feature observed in 19 out of the 23 countries reporting data within this region (82.6%). In the Americas, IVD embryos were collected more frequently from dairy breeds only in Canada (56.0%) and Colombia (68.7%). Sex-sorted semen was used in 31.7% of flushes in dairy breeds, but in only 4.9% of the flushes in beef breeds.

The proportions of frozen-thawed or fresh IVD embryos transferred in 2021 (60.5% and 39.5%, respectively) were similar to those observed in 2020 (59.5% *vs*. 40.5%, respectively). The transfer of cryopreserved embryos was greater in beef than in dairy breeds (66.9% *vs.* 53.4%). The proportion of transferred frozen-thawed embryos was slightly greater in North America than in South America or Europe (62.1% *vs*. 53.9% and 58.5%, respectively).

Cattle, IVP. The production of embryos *in vitro* in 2021 is shown in Table 6 (OPU-collected oocytes) and Table 7 (abattoir-derived oocytes). We observed a remarkable increase in the number of IVP embryos reported in 2021 (1,521,018 *vs.* 1,156,422 in 2020; +31.5%), which led to the increase of 25.6% in the world's total, the greatest since 2003. The number of IVP embryos recorded in 2021 increased in all regions but Europe (−10.7%), compared with 2020. As observed in 2020, European numbers were affected by the retraction in the ET activity in Russia, which accounted for 34.5% of the IVP embryos from that continent in 2020, but almost ceased the activity in 2021 (−99.9%). Conversely, in the Netherlands and Germany, the second and third largest countries in regard to IVP embryo numbers in Europe, recorded substantial increases in 2021 (+22.9% and +9.1%, respectively).

The trends observed for IVP embryos in 2021 were mostly driven by the scenario in the Americas. North America and South America accounted for 95.7% of the IVP embryos, and in both regions, numbers increased in a similar fashion (+32.1% and +35.3%, respectively, compared with

Table 8. Transfer of bovine *in vitro*-produced (IVP) embryos by region in 2021

Region/	Embryos transferred							
	OPU				Abattoir			
		Frozen				Frozen		
Country	**Fresh**	**Domestic**	**Foreign**	**Total**	**Fresh**	**Domestic**	**Foreign**	**Total**
Africa	1,239	4,143	0	5,382	0	0	0	0
Asia	0	0	0	0	0	0	0	0
Europe	9,917	11,576	253	21,746	11	218	0	229
North America	274,914	179,849	1,307	456,070	818	90	0	908
Oceania	13,164	4,772	0	17,936	0	0	0	0
South America	378,114	278,250	1,041	657,405	6,113	245	0	6,358
Total	**677,348**	**478,590**	**2,601**	**1,158,539**	**6,942**	**553**	**0**	**7,495**

Table 9. Micromanipulation of bovine embryos for sexing or genotyping in 2021

	Sexed		Genotyped	
Country	**IVD**	**IVP**	**IVD**	**IVP**
Canada	93	10,401	0	10,401
France	1,387	8	1,170	8
Germany	0	533	0	1
Netherlands	0	0	0	5,610
Spain	0	12	0	5
United States	37	0	0	0
Total	**1,517**	**10,954**	**1,170**	**16,025**

2020). A noticeable increase in IVP totals occurred in Mexico (+244.6%) and in Colombia (+187.3%). However, the increase observed in the United States (+22.0%) and in Brazil (+20.6%), the first and second largest countries in IVP numbers, resulted in an additional 115,768 and 75,534 embryos in the world's totals, respectively. It is noteworthy that numbers from Brazil are likely to be significantly underestimated, due to the evident difference between the number of embryos reported to the breeders' associations and the number of ET sheaths sold in the country (1,189,593 in 2021). This difference increased from 8.1% in 2015 to 171.6% in 2021, perhaps effect of the growing market of unregistered, low-cost embryos in Brazil.

A contrasting situation occurs regarding the use of FSH stimulation before ovum pick-up (OPU). In all European countries and in Canada, the vast majority of the IVP embryos recorded have been produced after FSH stimulation (99.3% and 100.0%, respectively), whereas in other North

Table 10. Sheep: *in vivo*-derived [IVD] and *in vitro*-produced [IVP] embryo collections and transfers in 2021

	IVD Embryos					IVP embryos					
			Embryo transfer						Embryo transfer		
				Frozen						Frozen	
Region/ Country	**Flushes**	**Embryos**	**Fresh**	**Domestic**	**Foreign**	**Donors**	**Oocytes**	**Embryos**	**Fresh**	**Domestic**	**Foreign**
Europe											
Greece	3	13	0	0	0	0	0	0	0	0	0
Romania	2	27	27	0	0	0	0	0	0	0	0
Russian Fed.	0	0	0	0	1,878	0	0	0	0	0	0
Serbia	4	32	0	6	0	0	0	0	0	0	0
Spain	33	320	0	60	0	18	384	180	0	0	0
UK	167	993	27,593	641	0	0	0	0	0	0	0
Total	209	1,385	27,620	707	1,878	18	384	180	0	0	0
North America											
Canada	24	76	28	414	6	0	0	0	0	0	0
Mexico	83	589	224	125	0	0	0	0	0	0	0
USA	1,623	9,619	7,462	768	0	156	1,620	446	353	93	0
Total	1,730	10,284	7,714	1,307	6	156	1,620	446	353	93	0
Oceania											
Australia	2,924	21,878	19,536	859	0	0	0	0	0	0	0
Total	2,924	21,878	19,536	859	0	0	0	0	0	0	0
South America											
Brazil	918	7,636	5,902	1,311	0	0	0	0	0	0	0
Total	918	7,636	5,902	1,311	0	0	0	0	0	0	0
Grand Total	**5,781**	**41,183**	**60,772**	**4,184**	**1,884**	**174**	**2,004**	**626**	**353**	**93**	**0**

Table 11. Goats: *in vivo*-derived [IVD] and *in vitro*-produced [IVP] embryo collections and transfers in 2021

Region/ Country	IVD Embryos					IVP embryos					
			Embryo transfer						Embryo transfer		
				Frozen						Frozen	
	Flushes	Embryos	Fresh	Domestic	Foreign	Donors	Oocytes	Embryos	Fresh	Domestic	Foreign
Europe											
France	0	0	0	3	0	0	0	0	0	0	0
Spain	48	648	0	200	0	25	504	268	0	0	0
Total	48	648	0	203	0	25	504	268	0	0	0
North America											
Canada	15	43	4	0	0	0	0	0	0	0	0
Mexico	0	0	0	0	0	25	312	87	87	0	0
USA	1,199	8,646	9,131	417	0	942	22,175	6,000	4,026	1,489	0
Total	1,214	8,689	9,135	417	0	967	22,487	6,087	4,113	1,489	0
Oceania											
Australia	189	1,856	540	0	0	0	0	0	0	0	0
Total	189	1,856	540	0	0	0	0	0	0	0	0
Grand Total	**1,451**	**11,193**	**9,675**	**620**	**0**	**992**	**22,991**	**6,355**	**4,113**	**1,489**	**0**

American countries as well as Oceania and South America, FSH is rarely used (2.4% of the OPUs).

The number of IVP embryos generated using abattoir-derived oocytes in 2020 increased in Europe (+56.2%) and North America (+97.1%), but decreased in South America (−29.0%), resulting in an overall decrease of 7.5% (21,882 *vs.* 23,649 in 2020). The proportion of IVP embryos generated from abattoir oocytes remains very low (1.4% of total).

The number of transfers of IVP embryos in 2021 is shown in Table 8. Both the absolute number and the proportion of IVP embryos actually transferred in 2021 increased compared with 2020 (1,166,034 [76.7%] *vs.* 878,181 [75.9%], respectively). As expected, the number of IVP embryo transfers decreased in Europe (−37.8% relative to 2020), and increased elsewhere (+29.4% in Africa, +34.5% in North America, +23.1% in Oceania, and +37.0% in South America). Although the United States recorded more IVP embryo production than Brazil (642,559 *vs*. 441,787, respectively), the proportion of embryos actually transferred was lesser in the former compared with the latter (56.5% *vs*. 98.5%). Thus, Brazil remains as the leader in transfers of IVP embryos worldwide (435,359, corresponding to 36.6% of the world total).

The proportion of frozen-thawed IVP embryos transferred in 2021 was slightly greater than in 2020 (41.3% *vs*. 39.5%, respectively), but has increased consistently over the last years (it was <10% in 2012). This, combined with the current trend toward a rapid expansion in the use of *in vitro* technologies, accounted for the growing share of cryopreserved IVP embryos in the total of transfers, which reached 32.6% in 2021.

Table 9 shows data regarding embryos micromanipulated for sexing or genotyping in 2021. These numbers are likely underestimated, but are useful to illustrate the general trends for these technologies. Consistently with what has been observed in previous years, both sexing and genotyping decreased in IVD, whereas increased in IVP embryos (−39.3% and −22.1% *vs*. +11.4% and +14.9%, respectively).

Other species. The numbers of IVD and IVP embryos reported in 2021 in species other than cattle are shown in Tables 10 (sheep), 11 (goats), 12 (horses) and 13 (cervids and buffaloes). Embryo activity in sheep followed the trends observed in cattle, with an increase in both numbers of IVD and IVP embryos recorded and transferred in 2021 (+38.1% and +104.4% for IVD, and +344.0% and +379.6% for IVP, respectively, compared with 2020). Australia leads the collection and transfer of IVD sheep embryos (53.1% and 30.5% of world totals, respectively), whereas the USA accounted for most of IVP sheep embryos collected and transferred in 2021 (72.2% and 100.0%, respectively). The majority of IVD and IVP sheep embryos were transferred fresh (90.0% and 79.1%, respectively).

A contrasting scenario has been observed for goat embryos. The total number of embryos recorded increased 13.6% from 2020 to 2021. However, the number of IVD embryos collected and transferred decreased (−15.1% and −17.9%, respectively), whereas the numbers of IVP embryos increased substantially (+179.3% and +305.6%, respectively). As observed in 2020, the United States accounted for most of the IVD and IVP goat embryos (77.2% and 94.4%, respectively) reported in 2021 worldwide.

Table 12. Horses: *in vivo*-derived [IVD] and *in vitro*-produced [IVP] embryo collections and transfers in 2021

Region/ Country	IVD Embryos					IVP embryos					
			Embryo transfer						Embryo transfer		
				Frozen						Frozen	
	Flushes	Embryos	Fresh	Domestic	Foreign	Donors	Oocytes	Embryos	Fresh	Domestic	Foreign
Europe											
Estonia	10	8	8	0	0	0	0	0	0	0	7
France	1,156	624	846	0	0	0	0	0	0	45	0
Italy	0	0	0	0	0	3,440	45,836	6,764	7	727	0
Poland	0	0	54	0	0	0	0	0	0	0	34
Portugal	216	124	0	0	0	6	45	0	0	0	0
Russian Fed.	16	12	11	0	0	0	0	0	0	0	0
Spain	4	4	0	0	0	0	0	0	0	0	0
Sweden	33	0	0	0	0	0	0	0	23	0	0
Switzerland	0	0	0	0	0	41	116	11	0	0	0
Total	1,435	772	919	0	0	3,487	45,997	6,775	30	772	41
North America											
Canada	39	19	18	1	0	0	0	0	0	0	0
Mexico	18	17	17	0	0	0	0	0	0	0	0
USA	852	542	1,268	22	0	1,203	7,486	1,347	1,347	278	0
Total	909	578	1,303	23	0	1,203	7,486	1,347	1,347	278	0
South America											
Brazil	40,250	23,420	23,280	0	0	0	17,400	3,480	1,860	1,620	0
Colombia	1,211	705	677	3	0	51	284	17	76	54	0
Total	41,461	24,125	23,957	3	0	51	17,684	3,497	1,936	1,674	0
Grand Total	**43,805**	**25,475**	**26,179**	**26**	**0**	**4,741**	**71,167**	**11,619**	**3,313**	**2,724**	**41**

In horses, the increase in the number of embryos recorded in 2021 (+9.6%) was mainly driven by the increase in IVP (+34.5%), as the number of IVD embryos remained similar to 2020 (25,475 *vs.* 25,219, respectively, +1.0%). Once again, Brazil leads the collection of IVD horse embryos (23,420; 91.9% of world total), whereas Italy was the country with more IVP embryos (6,764; 58.2% of world total). Italy, however, exported 51.7% of the IVP embryos and only 7 fresh and 727 frozen-thawed embryos were transferred within the country.

In 2021, the number of cervid embryos reported decreased substantially (−89.1%), partially due to the lack of data from New Zealand, but also due to the reduction in numbers from the USA (−91.4%). On the other hand, the number of IVP embryos reported increased (from 15 to 226, +1,406.7%), thanks to Mexico and the United States. Embryo transfer activity in buffalo was reported only by the United States, and only for IVP embryos.

Exports. The numbers of embryo exports are shown in Table 14. In cattle, the number of IVD embryos exported in 2021 decreased in dairy (−10.1%) but increased in beef breeds (+40.5%), resulting in an overall increase of 2.0% relative to 2020 (30,808 *vs.* 30,211). The number of IVP cattle embryos exported in 2021 decreased (−6.2%). Nevertheless, the number of countries reporting exports of IVP embryos increased from 4 in 2020 to 7 in 2021. All exported cattle IVP embryos were produced with oocytes recovered by OPU.

Three countries reported exports of IVD sheep embryos, which increased by 379.6% (1,199 *vs.* 250 in 2020). Moreover, 200 goat IVD embryos were exported by Spain. Italy accounted for all horse IVP embryos exported, which increased 30.2% compared with 2020.

Historical Series and Trends

The historical series of cattle embryo production (IVD, IVP, and total) in the past 20 years (2002 to 2021) is shown in Figure 2. The current trend of growth in world total has been already detected in 2020. In 2021, however, we observed a steep rise (31.5%) in the number of IVP embryos compared with 2020, the greater rise since 2017. Actually, in absolute numbers this was the greatest change from the immediate previous year (+363,596 embryos) in our historical series. Due to the small change in the number of IVD em-

Table 13. Other species: *in vivo*-derived [IVD] and *in vitro*-produced [IVP] embryo collections and transfers in 2021

Region/ Country	IVD Embryos					IVP embryos					
			Embryo transfer						Embryo transfer		
				Frozen						Frozen	
	Flushes	Embryos	Fresh	Domestic	Foreign	Donors	Oocytes	Embryos	Fresh	Domestic	Foreign
Cervids											
Argentina	13	57	0	0	0	0	0	0	0	0	0
Mexico	0	0	0	0	0	18	198	48	48	0	0
United States	60	86	32	0	0	190	1,515	178	18	160	0
Total	73	143	32	0	0	208	1,713	226	66	160	0
Buffalo											
United States	0	0	0	0	0	6	94	11	0	11	0
Total	0	0	0	0	0	6	94	11	0	11	0

Table 14. Countries exporting embryos in 2021

Region/ Country	Bovine				Sheep	Goats	Horse
	IVD		IVP				
	Dairy	Beef	OPU	Abattoir	IVD	IVD	IVP
Europe							
Belgium	16	36	0	0	0	0	0
Denmark	33	3	0	0	0	0	0
Estonia	0	10	0	0	0	0	0
Finland	543	0	273	0	0	0	0
France	176	369	53	0	0	0	0
Germany	184	0	0	0	0	0	0
Italy	0	0	0	0	0	0	3,498
Norway	0	20	0	0	0	0	0
Spain	55	480	0	0	80	200	0
Switzerland	81	0	909	0	0	0	3
United Kingdom	0	168	123	0	568	0	0
Total	1,088	1,086	1,358	0	648	200	3,501
North America							
Canada	3,405	4,805	1,605	0	0	0	0
United States	14,861	2,333	6,306	0	0	0	0
Total	18,266	7,138	7,911	0	0	0	0
Oceania							
Australia	22	1,938	0	0	551	0	0
Total	22	1,938	0	0	551	0	0
South America							
Argentina	0	1,270	0	0	0	0	0
Brazil	0	0	1,152	0	0	0	0
Total	0	1,270	1,152	0	0	0	0
Grand Total	**19,376**	**11,432**	**10,421**	**0**	**1,199**	**200**	**3,501**

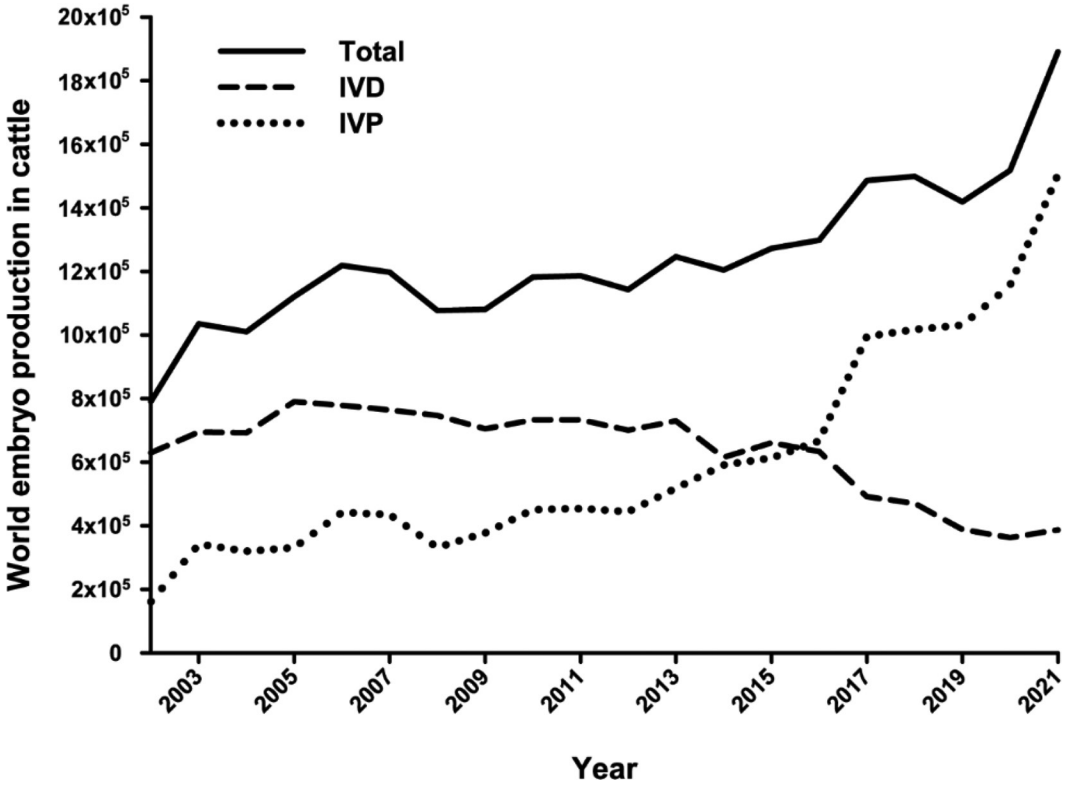

Figure 2. Number of bovine embryos (*in vivo*-derived [IVD], *in vitro*-produced [IVP], and total) recorded in the period 2002-2021.

bryos (+6.8%), the rise in IVP numbers reflected directly on the total numbers. The current growth rate of IVP embryos is similar to the one observed in the early 2000s, (average +35.8% per year from 2002 to 2006), which was followed by a period of slower increase in numbers (+4.6%) between 2007 to 2015. On the other hand, in spite of the increase observed in 2021, the number of IVD embryos has declined consistently over the past years (on average −4.0% per year), after reaching its peak in 2005 (789,972).

The numbers of IVP and IVD embryos recorded per region are shown in Figures 3A and 3B, respectively. The trend favoring IVP embryos in North and South America, regions accounting for most of the embryos produced worldwide, has been similar (+32.1% and +35.3%, respectively)

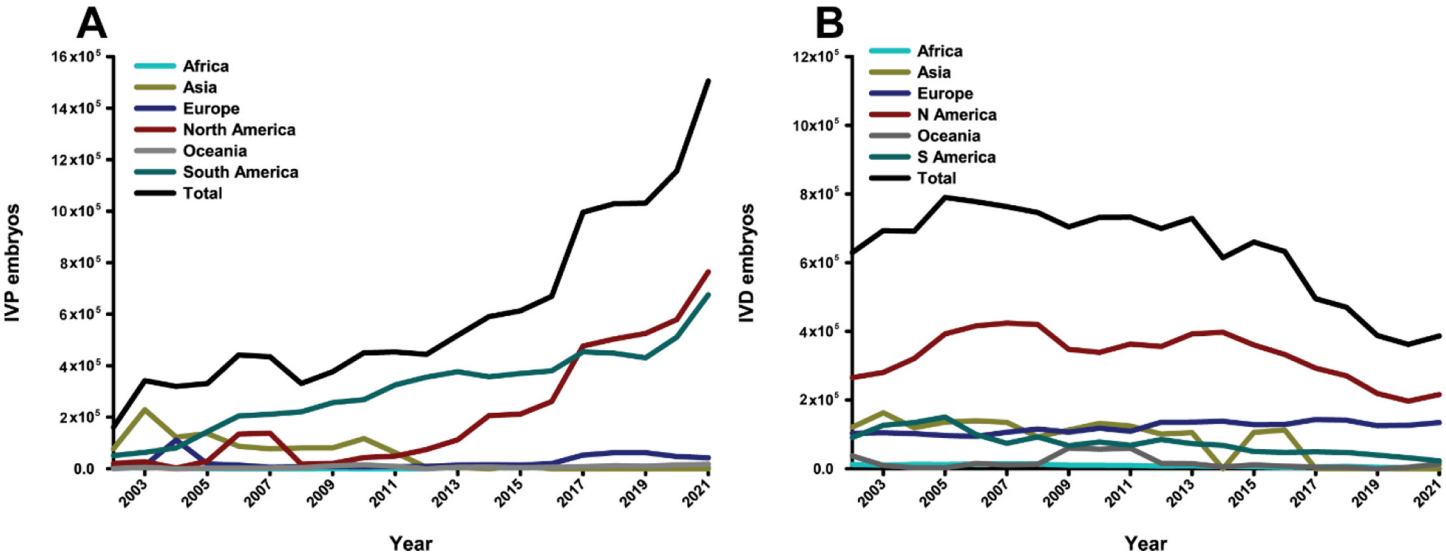

Figure 3. Number of embryos produced or collected in cattle in the period of 2002-2021, by continent. (A) *In vitro*-produced [IVP] embryos; (B) *In vivo*-derived [IVD] embryos.

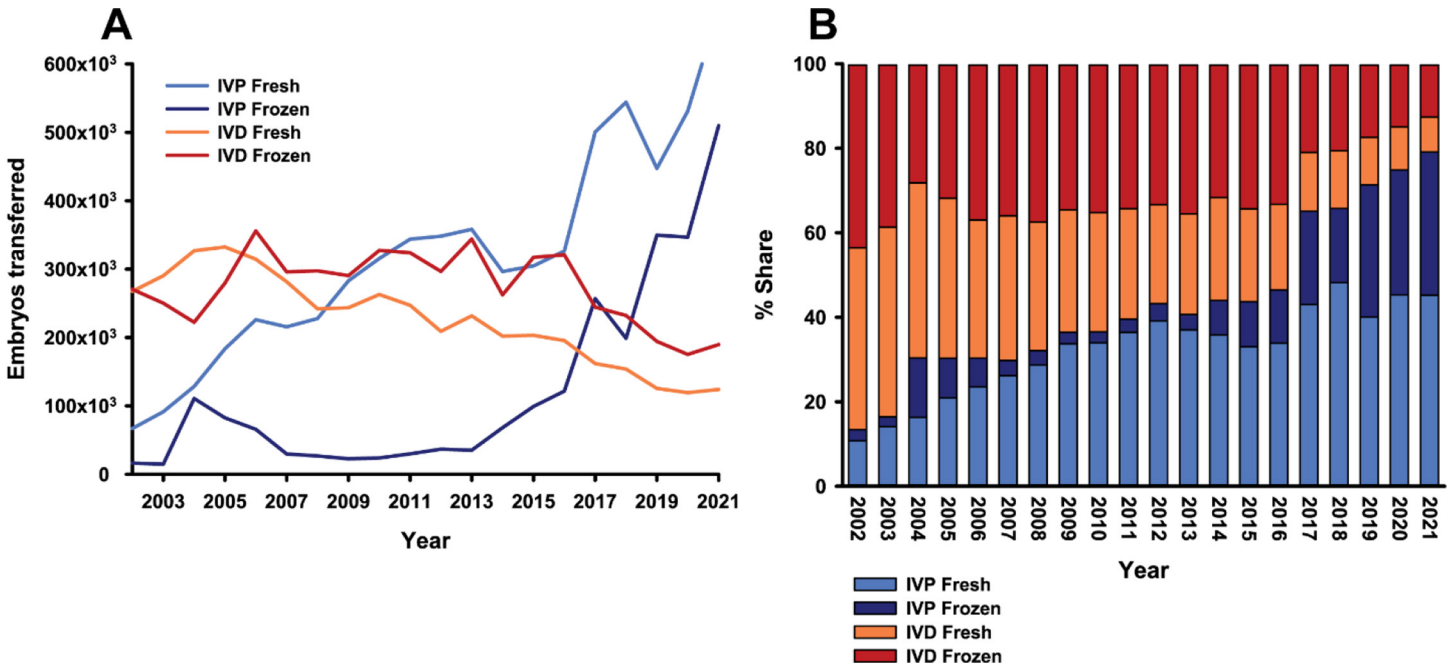

Figure 4. Embryo transfers in cattle in the period of 2002-2021, according to the technique used (*in vivo*-derived [IVD] or *in vitro*-produced [IVP]) and type of embryo (fresh or frozen-thawed). (A) Number of embryos transferred; (B) Percent share of the total embryo transfers per year.

and are in contrast with Europe, where numbers declined (−10.7%). Conversely, the rebound in the number of IVD embryos was observed in North (+9.7%), but not in South America (−27.7%), region in which the vast majority of embryos recorded is currently produced *in vitro* (96.8%).

The number and the percent share of frozen-thawed IVD and IVP embryos transferred from 2002 to 2021 are shown in Figures 4A and 4B. As expected, the proportion of IVP embryos transferred in 2021 increased from 74.9% to 78.8% of the total (IVP+IVD). However, this increase was associated with a rise in use of cryopreserved embryos, rather than of fresh embryos, when compared with 2020 (from 29.6% to 32.6% *vs.* 45.3% to 46.2% of all embryos transferred, respectively). The share of IVD embryos transferred as frozen-thawed or fresh decreased in the same proportion (from 10.2% to 8.4% and from 14.9% to 12.8%, respectively).

Embryo Industry Rank

The absolute numbers of embryos produced and transferred provide a dimension of the embryo industry within each country. These numbers, however, are only an indirect indicator of the average adoption of the technology by farmers. Therefore, we here propose an index based on the number of embryos produced per 10,000 heads of cattle, aiming to evaluate the intensity of embryo technologies use by each country.

Based on this criterium, the United States is not only the country with the greatest bovine embryo production, but also ranks first in intensity of ET use, with an index of 85.5. In contrast, Brazil ranks second in embryo production, but this country has the largest commercial cattle inventory in the world; thus, Brazil ranks only 16th in the intensity index. The difference between total embryo production and the intensity of technology use is depicted as density maps in Figure 5 (A and B).

5. Discussion

The increase in the number of embryos collected and transferred worldwide in farm species observed since 2020 has been consistent with the long-term trends of the embryo industry. Nevertheless, it contrasts with the expected effects of the economic and social crisis subsequent to the outbreak of Covid-19 and the declaration of a global pandemic status by the World Health Organization (WHO) on March 11, 2019.[2] In fact, to some extent the pandemic actually had a negative impact on the embryo industry, particularly by disturbing logistics and supply chains of consumables, media, and plasticware.[3] This negative impact, however, was counterbalanced by a growing international demand for food and by the rise in prices of animal protein, which directly boosted the pursuit for superior genetics and, ultimately, for the use of embryo technologies, as discussed previously.[4]

In this regard, we thus speculate that this conjuncture has made 2021 even more favorable for the embryo industry, explaining the steep rise in ET numbers, particularly in cattle and sheep. Although the peak of deaths during the pandemic occurred in 2021,[5] the development of vaccines and rapid immunization of a large percentage of the population created the economic conditions for a rebound in global GDP

Table 15. Top 20 countries according to the ET intensity index in 2021. 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
United States	802,047	1	93,793,300	3	85.5	1
Netherlands	30,909	11	3,691,000	66	83.7	2
Canada	80,677	6	11,265,000	32	71.6	3
Panama	7,514	15	1,505,500	97	49.9	4
Finland	3,613	24	835,380	111	43.2	5
Colombia	111,917	3	28,245,262	13	39.6	6
Denmark	5,766	17	1,500,000	98	38.4	7
Germany	37,040	8	11,301,860	31	32.8	8
Switzerland	4,877	20	1,515,023	96	32.2	9
Mexico	97,671	4	35,639,209	9	27.4	10
Italy	17,124	12	6,400,040	44	26.8	11
Costa Rica	3,793	22	1,427,793	99	26.6	12
France	41,900	7	17,789,250	21	23.6	13
Paraguay	32,140	9	14,026,143	26	22.9	14
Norway	1,972	28	869,136	110	22.7	15
Brazil	449,867	2	218,150,298	1	20.6	16
Austria	3,753	23	1,855,430	89	20.2	17
Argentina	92,355	5	54,460,799	7	17.0	18
Australia	31,095	10	23,503,238	15	13.2	19
Chile	4,142	21	3,196,740	67	13.0	20

[1]Total of embryos (IVD + IVP) recorded in 2021

[2]According to FaoStat 2020[1]

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

[4]Embryos recorded per 10,000 cattle heads

(from −3.3% in 2020 to +5.8% in 2021[6]). On the other hand, international meat prices remained high, reflecting on the demand for ET services and embryo market perspectives.[3] Clear evidence to support the positive scenario of the embryo industry observed in 2021 is the remarkable raise in the number of IVP embryos recorded and transferred, which for the first time reached 1.5 million and 1.1 million units, respectively.

All countries ranking on the top 10 in embryo production in 2020 recorded increase in 2021 numbers. Moreover, in addition to Argentina, Brazil, Canada, and the United States, two more countries reported over 50,000 embryos: Colombia and Mexico. The heated demand for ET is also likely to explain the shift in the previous trend toward a decrease in the records of IVD embryos observed since 2015. Instead, an increase in use of IVD embryos was observed in North America and Europe. Not in South America though. Still, the contribution of IVD embryos to the totals in the latter was already very low (<10%) even before the pandemic, and the favorable scenario for ET in 2021 seemed not enough to change this.

Despite the milestones reached, one shall consider that the current numbers may still be most likely underestimated. Since 2017, we do not receive ET data from Japan, which used to be the country with the most active embryo industry in Asia. Moreover, embryo export data provide evidence of ongoing ET activity in other countries within that continent, none of them reporting data to the IETS. In some particular cases (e.g., China), the numbers of embryos imported are not neglectable, and it is not unlikely that local embryo production is going on too. Another trend to watch is the emergence of new markets that may skip the current data retrieval procedures and, thus, lead to underreporting. This seems to be the case in Brazil, where large-scale *in vitro* embryo production programs have been used to generate replacement heifers for small farmers or zebu × taurus crossbreds for feedlots and the meat market, which are usually not reported to the breeder's associations. In fact, the difference between the number of ET sheaths sales and embryos actually reported has been progressively increasing since 2015 and suggests that less than half of the embryos actually produced may have been reported in 2021. Altogether, these underreport-

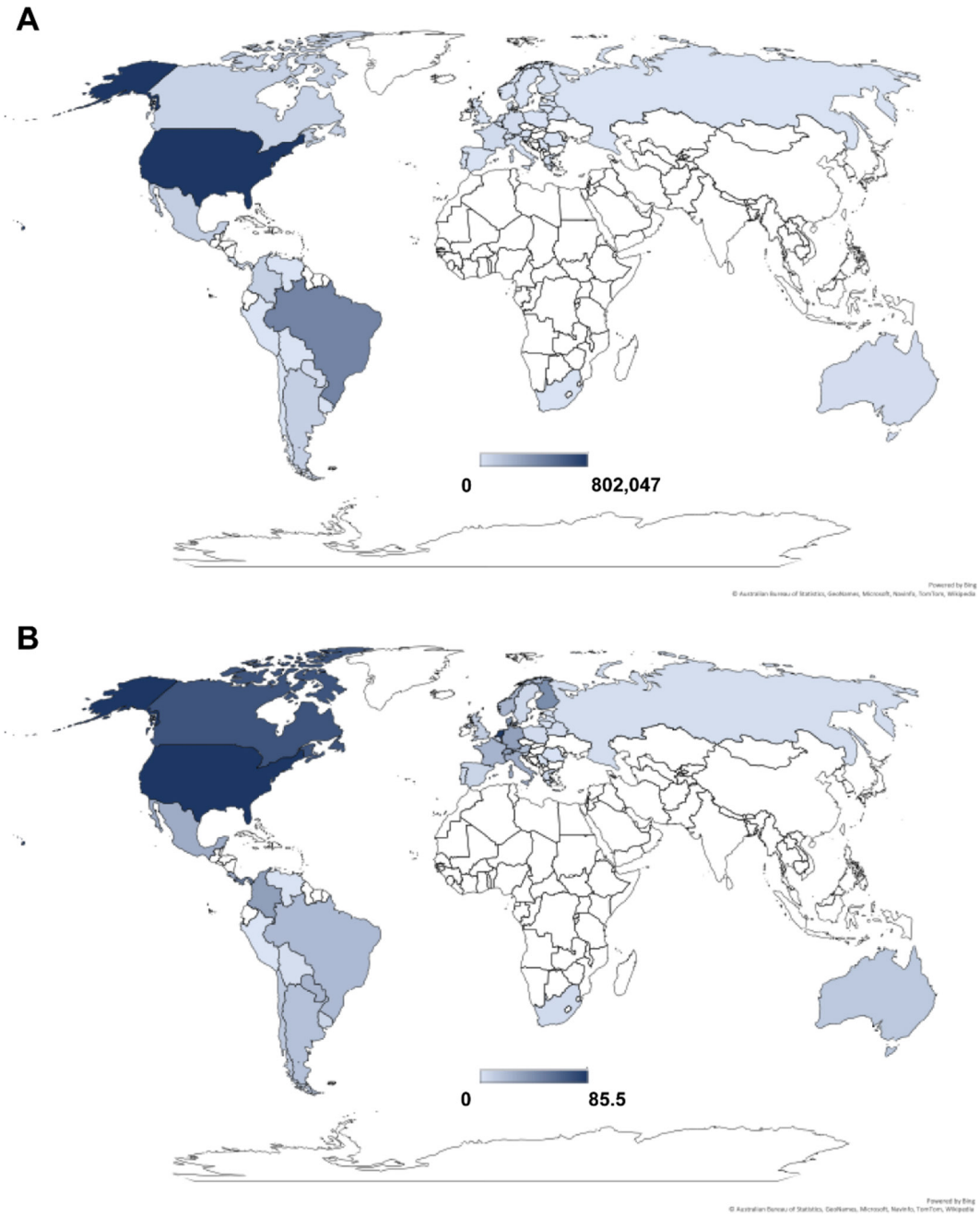

Figure 5. World density map depicting (A) total bovine embryo production, and (B) number of embryos per 10,000 cattle heads in each country in 2021. Image generated using Microsoft Excel.

ing scenarios may have hidden the real importance of the embryo industry for livestock production worldwide. Still, data available provides a good picture of the main trends and potentials of the ET technology, which may be not fully understood yet. The current rise in IVP numbers show how suitable the technology is to timely respond to market demands, either by intensifying animal breeding programs or exploring new market niches.

Lastly, we propose a newly created index to evaluate not only the raw numbers but also the intensity of ET technologies use among distinct countries. After ranking by this index, we were able to have a better view of the importance of embryo technologies in countries with relatively small absolute numbers, such as Panama or Finland. Additionally, we can forecast a potential for expansion of the embryo market in countries like Argentina, Australia, and Brazil, which have large cattle inventories (almost 300 million heads of cattle together; 18.7% of the world total) and an already established and active embryo industry, but still rank low on the intensity index list (18th, 19th, and 16th, respectively). Similarly, we could use this index in other farm species to speculate about the potential impact and future development

of embryo technologies, considering herd size and the importance of the livestock sector for the economy in a given country.

6. Acknowledgments

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 thank Luiz G. Siqueira for reviewing this report.

7. References

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Appendix 1: National data collectors in 2021

Region/Country	Collector	Region/Country	Collector
Africa		**Europe**	
Rep South Africa	Morne de la Rey	AETE	Héléne Quinton
		Austria	Friedrich Führer
Central America		Belgium	Peter Vercauteren, Isabelle Donnay
Panama	Luis Nasser	Denmark	Henrik Callesen
		Finland	Seija Vahtiala
North America		France	Serge Lacaze
Canada	Reuben Mapletoft (CETA)	Germany	Hubert Cramer
Mexico	Salvador Romo, ABS	Greece	Foteini Samartzi
United States	Daniela Demetrio (AETA)	Ireland	Patrick Lonergan
		Italy	Giovanna Lazzari
South America		Latvia	Vita Antane
Argentina (bovine)	Gabriel Bo	Lithuania	Raisa Nainiene
Brazil (bovine)	Joao Viana	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	Joao Viana *, ABS	Russian Federation	Denis Knurow, Viktor Madison, ABS
Paraguay	Joao Viana *, Gabriel Soria	Serbia	Aleksandar Milovanovic
Peru	Edwin Mellisho	Slovenia	Janko Mrkun
Uruguay	Joao Viana *, ABS	Spain	Daniel Martinez Bello, CETA
Venezuela	Joao Viana *, ABS	Sweden	Renée Båge
		Switzerland	Rainer Saner
Oceania		United Kingdom	Roger Sturmey, Brian Graham, CETA
Australia	Cedric M Wise, Genstock WA,		
News Zealand	Reuben Mapletoft (CETA)		

*Data collected/organized by the Chair

Appendix 2: Collection of bovine *in vivo*-derived (IVD) embryos by region and country in 2021

Region/ Country	Flushes						Collected					
	Conventional semen			Sexed semen			Total ova			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Europe												
Austria	522	6	528	9	0	9	5,316	30	5,346	3,733	20	3,753
Belarus	194	0	194	101	0	101	1,681	0	1,681	1,097	0	1,097
Belgium	13	652	665	0	0	0	78	3,677	3,755	22	2,407	2,429
Denmark	842	27	869	0	0	0	7,808	363	8,171	5,489	277	5,766
Estonia	0	12	12	0	0	0	0	64	64	0	64	64
Finland	448	0	448	15	0	15	3,893	0	3,893	2,637	0	2,637
France	3,578	1,361	4,939	1,306	102	1,408	46,298	16,213	62,511	27,595	9,463	37,058
Germany	4,045	535	4,580	0	0	0	36,805	5,451	42,256	25,721	3,494	29,215
Greece	0	0	0	4	0	4	0	0	0	17	0	17
Italy	1,095	120	1,215	1,155	0	1,155	23,171	1,224	24,395	15,980	816	16,796
Latvia	2	0	2	2	0	2	31	0	31	18	0	18
Lithuania	4	0	4	0	0	0	6	0	6	3	0	3
Netherlands	2,605	0	2,605	22	0	22	21,823	0	21,823	14,543	0	14,543
Norway	270	20	290	4	0	4	1,900	150	2,050	1,850	98	1,948
Poland	140	17	157	109	0	109	2,050	200	2,250	1,705	111	1,816
Portugal	2	22	24	76	0	76	626	289	915	352	117	469
Romania	13	0	13	4	0	4	55	0	55	49	0	49
Russian Federation	117	572	689	199	0	199	2,647	5,225	7,872	1,557	4,305	5,862
Serbia	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	21	7	28	7	4	11	135	40	175	94	31	125
Spain	86	164	250	147	16	163	2,068	2,585	4,653	1,042	898	1,940
Sweden	140	7	147	5	0	5	1,349	0	1,349	858	0	858
Switzerland	128	27	155	297	0	297	5,615	224	5,839	3,159	162	3,321
United Kingdom	182	635	817	62	0	62	2,528	6,903	9,431	1,167	3,435	4,602
North America												
Canada	2,117	3,130	5,247	2,703	28	2,731	51,317	41,069	92,386	28,696	22,552	51,248
Mexico	0	792	792	0	51	51	0	6,132	6,132	0	5,009	5,009
United States	5,478	17,260	22,738	4,131	1,299	5,430	74,809	200,197	275,006	47,339	112,149	159,488
Oceania												
Australia	198	2,126	2,324	208	74	282	3,365	9,341	12,706	1,539	11,875	13,414
South America												
Argentina	291	2,247	2,538	142	13	155	2,698	19,604	22,302	2,048	12,483	14,531
Brazil	556	1,040	1,596	0	0	0	2,814	5,266	8,080	2,814	5,266	8,080
Colombia	21	12	33	20	4	24	176	83	259	152	66	218
Panama	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3: Transfer of bovine *in vivo*-derived (IVD) embryos by region and country in 2021

Region/ Country	Fresh embryos				Frozen domestic embryos				Frozen imported embryos			
	Dairy	Beef	Unsorted	Total	Dairy	Beef	Unsorted	Total	Dairy	Beef	Unsorted	Total
Europe												
Austria	1,451	6	0	1,457	1,863	6	0	1,869	24	12	0	36
Belarus	791	0	0	791	390	0	0	390	0	87	0	87
Belgium	2	493	0	495	207	2,644	0	2,851	364	264	0	628
Denmark	3,155	41	0	3,196	1,566	139	0	1,705	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	7	0	7
Finland	773	13	0	786	1,359	10	0	1,369	95	53	0	148
France	13,704	2,924	0	16,628	11,068	3,911	0	14,979	1,113	525	0	1,638
Germany	11,476	896	0	12,372	14,349	1,930	0	16,279	0	0	0	0
Greece	0	0	0	0	0	0	0	0	0	0	0	0
Italy	6,580	120	0	6,700	1,860	0	0	1,860	0	0	0	0
Latvia	7	0	0	7	7	0	0	7	4	0	0	4
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	3,055	0	0	3,055	9,301	0	0	9,301	0	0	0	0
Norway	20	20	0	40	1,737	98	0	1,835	50	30	0	80
Poland	1,029	43	0	1,072	357	0	0	357	55	19	0	74
Portugal	110	38	0	148	146	31	0	177	4	24	0	28
Romania	46	0	0	46	3	0	0	3	0	6	0	6
Russian Federation	113	0	0	113	1,434	4,501	0	5,935	259	38	0	297
Serbia	0	0	0	0	0	0	0	0	0	72	0	72
Slovenia	30	1	0	31	55	13	0	68	9	0	0	9
Spain	475	140	0	615	463	984	0	1,447	103	201	0	304
Sweden	648	0	0	648	1,093	0	0	1,093	0	0	0	0
Switzerland	773	34	0	807	2,650	25	0	2,675	450	0	0	450
United Kingdom	556	835	0	1,391	389	1,231	0	1,620	340	950	0	1,290
North America												
Canada	9,619	4,321	0	13,940	12,066	10,954	0	23,020	25	289	0	314
Mexico	0	3,756	0	3,756	0	1,206	0	1,206	0	0	183	183
United States	12,722	30,866	0	43,588	10,773	64,947	0	75,720	37	113	0	150
Oceania												
Australia	491	1,866	0	2,357	611	5,665	0	6,276	124	211	0	335
South America												
Argentina	1,027	4,232	0	5,259	792	5,510	0	6,302	118	67	0	185
Brazil	845	3,627	0	4,472	1,969	2,580	0	4,549	0	0	0	0
Colombia	152	66	28	246	152	45	57	254	0	86	86	172
Panama	0	0	0	0	0	0	0	0	0	120	0	120

Appendix 4: Production of bovine embryos *in vitro* (IVP) with OPU-collected oocytes by region and country in 2021

Region/ Country	Donor preparation					Oocytes					Transferrable embryos				
	Non-stimulated		Stimulated			Non-stimulated		Stimulated			Non-stimulated		Stimulated		
	Dairy	Beef	Dairy	Beef	Total	Dairy	Beef	Dairy	Beef	Total	Dairy	Beef	Dairy	Beef	Total
Africa															
Rep South Africa	0	1,026	0	0	1,.026	0	19,084	0	0	19,084	0	5,421	0	0	5,421
Europe															
Belarus	0	0	83	0	83	0	0	1,653	0	1,653	0	0	481	0	481
Finland	0	0	700	0	700	0	0	6,791	0	6,791	0	0	976	0	976
France	0	0	1,203	122	1,325	0	0	12,600	1,756	14,356	0	0	4,076	766	4,842
Germany	0	0	2,189	150	2,339	0	0	26,740	2,425	29,165	0	0	7,235	590	7,825
Italy	0	0	111	0	111	0	0	1,214	0	1,214	0	0	328	0	328
Netherlands	0	0	5,694	0	5,694	0	0	56,981	0	56,981	0	0	13,059	0	13,059
Norway	0	0	13	0	13	0	0	174	0	174	0	0	24	0	24
Poland	0	0	146	0	146	0	0	2,190	0	2,190	0	0	543	0	543
Romania	0	0	10	0	10	0	0	20	0	20	0	0	0	0	0
Russian Federation	13	0	0	0	13	7	0	0	0	7	5	0	0	0	5
Serbia	0	0	20	0	20	0	0	256	0	256	0	0	65	0	65
Spain	0	35	101	74	210	0	601	1,754	1,287	3,642	0	221	616	615	1,452
Switzerland	0	0	443	40	483	0	0	3,936	478	4,414	0	0	1,378	178	1,556
United Kingdom	0	0	207	513	720	0	0	4,028	4,979	9,007	0	0	937	1,931	2,868
North America															
Canada	2	0	4,007	1,214	5,223	21	0	45,404	17,115	62,540	0	0	22,590	6,338	28,928
Mexico	540	11,501	0	159	12,200	13,560	313,020	0	5,568	332,148	3,240	87,379	0	1,335	91,954
United States	86,517	46,141	0	0	132,658	1,619,442	1,098,441	0	0	2,717,883	327,103	315,108	0	0	642,211
Oceania															
Australia	0	3,933	95	1	4,029	0	75,657	477	4	76,138	0	17,555	126	0	17,681
South America															
Argentina	0	13,384	92	142	13,618	0	261,541	693	2,672	264,906	0	77,192	121	511	77,824
Bolivia	225	150	0	0	375	4,604	3,070	0	0	7,674	1,722	1,148	0	0	2,870
Brazil	64,014	21,596	0	0	85,610	856,910	431,937	0	0	1,288,847	257,073	172,775	0	0	429,848
Chile	1,191	595	0	0	1,786	14,244	7,122	0	0	21,366	2,761	1,381	0	0	4,142
Colombia	9,939	5,330	70	6,113	21,452	205,843	120,717	4,742	91,842	423,144	48,519	30,254	854	32,072	111,699
Costa Rica	258	516	0	0	774	5,607	11,215	0	0	16,822	1,264	2,529	0	0	3,793
Panama	271	1,505	0	0	1,776	2,495	19,349	0	0	21,844	623	6,891	0	0	7,514
Paraguay	0	3,003	0	0	3,003	0	80,350	0	0	80,350	0	32,140	0	0	32,140
Uruguay	0	2,206	0	0	2,206	0	28,660	0	0	28,660	0	8,101	0	0	8,101
Venezuela	0	286	0	0	286	0	3,642	0	0	3,642	0	986	0	0	986

Appendix 5: Production of bovine embryos *in vitro* (IVP) with abattoir-derived oocytes by region and country in 2021

Region/ Country	Batches			Oocytes			Transferrable embryos		
	Dairy	Beef	Total	Dairy	Beef	Total	Dairy	Beef	Total
Europe									
Greece	116	0	116	1,442	0	1,442	225	0	225
The Netherlands	1,975	0	1,975	28,143	0	28,143	3,307	0	3,307
Portugal	0	0	0	4,953	0	4,953	236	0	236
Slovenia	134	65	199	934	345	1,279	42	23	65
Spain	0	520	520	0	3,851	3,851	0	1,720	1,720
United Kingdom	297	439	736	3,340	4,907	8,247	902	1,931	2,833
North America									
Canada	0	0	0	2,095	0	2,095	501	0	501
Mexico	0	105	105	0	3,375	3,375	0	708	708
United States	0	0	0	0	0	0	64	284	348
South America									
Brazil	0	0	0	0	29847	29,847	0	11939	11,939

Appendix 6: Transfer and export of bovine *in vitro*-produced (IVP) embryos by region and country in 2021

Region/ Country	Embryos transferred							
	OPU				Abattoir			
	Fresh	Frozen		Total	Fresh	Frozen	Total	Exported
		Domestic	Foreign					
Africa								
Rep South Africa	1,239	4,143	0	5,382	0	0	0	0
Europe								
Belarus	211	34	0	245	4	9	13	0
Belgium	0	24	0	24	0	0	0	0
Finland	0	765	0	765	0	0	0	273
France	1,967	1,575	151	3,693	0	0	0	53
Germany	2,658	4,265	0	6,923	0	0	0	0
Netherlands	4,462	3,477	0	7,939	0	0	0	0
Norway	0	110	30	140	0	0	0	0
Poland	112	145	0	257	0	0	0	0
Portugal	0	0	44	44	0	0	0	0
Russian Federation	0	24	0	24	0	0	0	0
Serbia	0	7	0	7	0	0	0	0
Spain	183	244	0	427	7	194	201	0
Switzerland	0	0	0	0	0	0	0	909
United Kingdom	324	906	28	1,258	0	15	15	123
North America								
Canada	4,836	3,804	107	8,747	0	0	0	1,605
Mexico	63,494	19,784	1,200	84,478	818	90	908	0
United States	206,584	156,261	0	362,845	0	0	0	6,306

Region/ Country	Embryos transferred							
	OPU				Abattoir			
		Frozen						
	Fresh	Domestic	Foreign	Total	Fresh	Frozen	Total	Exported
Oceania								
Australia	13,164	4,772	0	17,936	0	0	0	0
South America								
Argentina	22,331	47,424	19	69,774	0	0	0	0
Bolivia	1,912	334	0	2,246	0	0	0	0
Brazil	273,807	155,194	0	429,001	6,113	245	6,358	1,152
Chile	1,050	2,644	0	3,694	0	0	0	0
Colombia	67,964	34,559	1,022	103,545	0	0	0	0
Costa Rica	1,983	1,151	0	3,134	0	0	0	0
Panama	3,490	1,715	0	5,205	0	0	0	0
Paraguay	2,134	29,716	0	31,850	0	0	0	0
Uruguay	2,801	5,299	0	8,100	0	0	0	0
Venezuela	642	214	0	856	0	0	0	0