Hybrid Zones, Bio-objectification and Microbiota in Human Breast Milk Banking

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Abstract: This paper critically examines hybridity and complexity in human biobanking, focusing on current forms of human milk banking in Madrid (Spain). We present and analyze three practices where human breast milk is stored and circulated: the "12 de Octubre" human milk bank, set in a neonatology unit and based on altruistic donations; informal human milk sharing among mothers; and drug-development practices that use donated human milk as a source of probiotics. Our analysis show that these practices rely on complex socio-technical assemblages, which are also characterised by hybrid zones and points of intersection between them. By understanding bacteria as a boundary object, we analyze the entanglements, disentanglements and re-entanglements of microbiota in the mechanisms of human milk bio-objectification that each of these biobanking practices entails. The distinctions or confusions between "virtuous" and "wicked" bacteria are part of a complex choreography where political, technical and sociocultural aspects get entangled.

Keywords: human milk banks; biobanking; intercorporeality; bio-objectification; microbiota.

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1. Introduction

While a common definition of biobanks equates them with the large, population-based repositories of biosamples and health-related information that have proliferated in recent decades, there are a wide variety of other places where cells, tissues, organs, fluids, genetic data and

other types of bodily materials are collected, processed, preserved and circulated – from blood and organ banks to tissue culture collections, egg and sperm banks, diagnostic archives or genetic databases. If the development of large-scale research biobanks is somehow recent, many of these other kinds of biobanks have a longer and richer history, entangled with the evolution of biosciences since the 19th century. However, all of them have proliferated in recent years, becoming an essential cornerstone of the bioeconomy (Pavone and Goven 2017). All biobanks share one thing: they rely on the procurement of biomaterials or biodata by individuals (Cooper and Waldby 2014; Santoro and Romero-Bachiller 2017). There are different forms by which biobanks can establish this procurement – from altruistic donation to direct selling, with many intermediate arrangements – but in any case, the generation of biovalue, in any of the many senses of the concept (Birch and Tyfield 2013), is not possible without it.

Scholarly attention to biobanks started to increase from the 2000s onwards. While bioethics has focused on debates which are still far from resolved about informed consent, property of the body and privacy, social sciences and STS have studied the socio-technical arrangements where biobanking takes place. In the beginning, most approaches in one way or another pursued a classification of different types of biobanks, a clarification on "what was new" about new biobanks – an elaboration of distinctions. For instance, the literature on new forms of private biobanking showed the difference between public systems, based on altruistic donation and search for the public good, and new commercial banks, based on market logics and individual profit. The way in which cord blood banking differed in public banks versus private companies was a particularly useful example (Waldby 2002a; Brown and Kraft 2006; Santoro 2009).

But gradually STS and social science perspectives on biobanks have changed their focus of interest: STS scholars increasingly emphasize the hybrid character of the widely different forms of biobanking. Comparative studies have shown the complex entanglements of biomedical practices, economic interests, ethical values and forms of public involvement that come together, sometimes in conflicting ways, in biobanks in different sectors of the global bioeconomy (Gottweiss and Lauss 2012). Whereas cord blood banking was once used as an example of the opposition between public and private regimes, current perspectives have focused on the blurring of boundaries between public and private banks, as well as on the growth of hybrid models (Brown and Williams 2015; Hauskeller and Beltrame 2016; Sleeboom-Faulkner and Chang 2016). From a feminist STS perspective, the notion of care has put complexity and ambivalence at the forefront of studies on biomedical practices – donation to biobanks among them (Mol, Moser and Pols 2010; Santoro and Romero-Bachiller 2017). The empirical literature on biobank donors and their motivations has also increasingly noted the complexity of values and logics behind donation,

which cannot be limited to the idea of "pure" altruism versus "pure" benefit/exploitation (Lipworth et al. 2011; Locock and Boylan 2016). Even informed consent in biobank donation appears to be a much messier affair now, related to personal as well as social motivations (Hoeyer and Linöe 2006), not to mention its role in other areas of biobanking directly linked to private companies, such as egg donation (Lafuente 2017).

In this paper, we want to pursue this line of investigation and critically examine hybridity and complexity in human milk biobanking. Human milk is a peculiar biomaterial: hybrid, intercorporeal in itself (Waldby, 2002b) and, like other liminal biomaterials, difficult to categorize – is it a food? A tissue? A drug, given its immunological properties? Or all of these things at once? Nevertheless, it was one of the first biomaterials to be standardized, banked and medicalized (Swanson 2014). As is the case with other body parts (Santoro 2011), human milk brings together ancient symbolic associations related to the mother-child link and novel scientific attributes – e.g. speculations on its possible use in cancer therapies. Taking on breast milk banking as an object of research is also interesting because human milk has always been fraught with tensions and controversies, perhaps even more so nowadays given the current panorama of renewed interest in the promotion of breastfeeding from medical institutions and other social collectives. New kinds of practices involving human milk are appearing, as can be seen in digital platforms and internet services where human milk can be shared altruistically or directly bought and sold (Geraghty et al. 2013). Another layer of tension which will surface throughout this article has to do with the increase in biomedical research on human milk and the recent proliferation of human milk labs (Palmquist 2015, 28), a trend which correlates with the growing presence of bioeconomic private companies interested in developing new commercial products in this area. Human milk banking intersects with all these conflicting dimensions at once.

The aim of the article is to explore practices of human milk banking in Madrid. We look into the official human milk bank (HBM), the 12 de Octubre Milk Bank, founded in 2007 as a hospital bank, which currently provides donated milk at a regional level. But we will also show that formal human milk banks are not the only form of biobanking in Madrid, and that there are other practices related to human milk collection, preservation and circulation. In particular, we will present two other places where human milk is stored and circulated, generating different forms of biovalue: informal human milk sharing between mothers, on the one hand, and drug-development practices that use donated human milk as a source of probiotics, on the other. Both of these practices, in different scales and forms, involve aspects of milk biobanking.

After presenting these three sets of practices, we will proceed to show their hybrid and complex character: how they come to be entangled and, to some extent, dependent on one another. These practices – and particularly the "activation" of donors, the willingness and capacity of

lactating women to donate – rely on complex assemblages, which are full of "hybrid zones" (Hauskeller and Beltrame 2016): things are messier (Law 2004) than they first appear to be.

But this is not the end of the story, as even if hybridity and complexity are evident in these biobanking practices, they have to be restricted, reduced, especially in more formalized and medicalized environments such as a human milk bank or a research lab. In the final section of the paper, we focus on the technical manipulation of human milk in each of these three scenarios and particularly on the way they deal with bacteria and microbiota present in human milk. Bio-objectification refers to processes "in which life is *made an object* in different settings – in and outside of the current truth regime of the contemporary biosciences" (Vermeulen et al. 2012, 3). In processes of bio-objectification, there is a need for purification, for separation. Technical manipulation, standardization and safety and quality precautions can be seen as performative forms of classification (Bowker and Star 1999). The three forms of human milk biobanking that we analyze imply different forms of bio-objectifying milk and of dealing with bacteria. If, as Mary Douglas (1966) argued, impurity and contamination are "matter out of place", what is the place of bacteria here? We argue that bacteria in these three scenarios function as a *boundary object* (Star and Griesemer 1989). Although they gain concrete significance in each particular case, and require specific interventions, bacteria are present in all three cases, "maintaining coherence across intersecting social worlds" (Star and Griesemer 1989, 393). Whether they may be virtuous or wicked, bacteria manipulation, control and regulation become key, then, in defining and performing different kinds of bio-objects, and different versions of what human milk is and does in each of these three scenarios.

2. Methodology and Research Procedures

This article stems from an ongoing research cluster on feminist epistemologies and health activism. Within that broader project our analysis of human milk banking started only recently, and it employs ethnographic and qualitative methods, as well as secondary analysis of protocols and medical and official literature. To date we have conducted ten semi-structured interviews with human milk donors, lactating mothers who suffer from mastitis and HBM coordination, and scientific and technical staff. We are still conducting interviews with HMB donors and we are planning to carry out a second round of field-work with recipient's mothers along with a deeper analysis of the emerging industry of human milk probiotics. HMB staff were contacted through their institutional email addresses. HMB donors and lactating mothers who suffered from mastitis were contacted through snowball sampling, opening lines in different mothering support groups chat and email lists. All the people interviewed were provided with written and oral information about the

research topic and procedures, and they all agreed both in writing and orally to the interviews, following our protocol of informed consent. In this paper, we will mostly focus on two in-depth interviews with donors, two ethnographic visits to the 12 de Octubre Milk Bank, with several on-site interviews with staff (June and November 2017), and auto-ethnographic notes from Carmen's own experiences with mastitis, use of human milk based probiotics and human milk bacterial analysis. We also surveyed scientific articles related to "our" milk bank and, as we will explain later, a patent on human milk microbiota.

3. Biobanking Practices around Human Breast Milk

A human milk bank is a medical institution that collects, screens, stores and processes expressed breast milk donated by lactating mothers, in order to distribute it to newborns – particularly to preterm babies and medically fragile infants who cannot be breastfed by their own mothers. To guarantee the safety and quality of the milk, HMBs implement different protocols, from selection of potential donors to sterility measures, immunological analyses of donors and samples, pasteurization and freezing (García Lara et al. 2012).

The history of HMBs dates back to the beginning of the 20th century. As Swanson (2014) explains in her historical account of blood, milk and sperm banks in the United States, the development of "milk stations" and other doctor-led initiatives since the 1910s that collected, analysed and distributed breast milk from wet nurses – properly monitored on their diet, habits and behaviour and instructed to maintain hygiene and sterility – was one of the first prefigurations of modern biobanks. Swanson suggests, in fact, that "human milk became the first body product to be institutionally organized in disembodied form" (Swanson 2014, 17). The creation of milk banks in different countries – Vienna's milk bank, opened in 1909, is generally considered to be the first – signalled the beginning of a process of medicalization which gradually obscured the long history of wet nursing and other traditional practices of surrogate breastfeeding (Palmquist, 2015: 26). During the second half of the century, changes in breastfeeding rates, pediatrics and social conceptions of lactation and motherhood, as well as biomedical research on human and bovine milk and epidemiological alarms – such as the emergence of HIV/AIDS during the 1980s, soon recognized to be transmitted via human milk –, accompanied transformations in the technical and social configuration of milk banking (Carroll 2014; Swanson 2014).

In Spain, however, the implementation of HMBs is quite recent and has more to do with contemporary developments in neonatal care. The first Spanish milk bank opened in 2001 in Majorca as part of a tissue and blood bank. Our case study, the 12 de Octubre Milk Bank, was initiated in 2007

in Madrid and was the first milk bank set up in a neonatology unit (an institutional location which has become the *de facto* model for most of the eleven banks created in Spain since then). Based on scientific evidence about the benefits of human milk compared to formula substitutes in the feeding of preterm and fragile newborns in Neonatal Intensive Care Units (NICUs), this bank currently provides donated human milk to very low birth weight preterm infants (under 1500 g) and newborns subjected to surgical interventions who cannot be breastfed by their mothers. Donated human milk is prescribed specifically to very low birth weight preterm infants, as human milk it is the only known prevention for *necrotizing enterocolitis*, a relatively common condition in preterm babies that consists of the necrosis of a portion of the bowel, causing high rates of infant mortality (Carroll 2014). While in its first six years of operation its services were limited to the hospital in which it is based, the bank has now become the center of a regional network which coordinates collection points and neonatology units in seven other public hospitals in Madrid and adjacent cities, and there are currently plans to extend the network to three more public hospitals in the region.

As with all HMBs, the 12 de Octubre Milk Bank relies on donations from lactating mothers who regularly express their milk, collect it and bring it to the bank. Since 2007 more than 1600 mothers have donated milk, approximately 250 each year, according to the bank coordinator. In significant contrast with the donation of other tissues, milk donation is not an isolated act, but a prolonged one where mothers are expected to provide milk on a continuous basis, accompanying their own lactation – most donors spend between 6 months and a year providing expressed milk, which they have to deliver to the bank each fortnight at most. Donors are motivated for altruistic reasons, but many are also "pushed" by personal experiences: a survey that the bank conducted with its donors between 2007 and 2010 revealed that 45% of donor mothers had had their own child hospitalized in a neonatal intensive care unit (Sierra Colomina et al, 2014). There is also a relationship with breastfeeding advocacy: the foundation of an HMB in a certain place is said to increase overall rates of breastfeeding in the area (García Lara et al. 2012). As we have seen in our fieldwork, and also according to the bank coordinator, a significant proportion of donors participate in groups and networks related to breastfeeding, and the bank itself targets support groups for recent mothers and midwives' networks in their donor recruitment strategy.

At first sight, the 12 de Octubre Milk Bank seems to be the only place where human breast milk biobanking happens in Madrid. But during our fieldwork we have come across two other scenarios where there are different practices that involve milk banking. The first one has to do with informal practices of human milk sharing. Milk sharing is a practice in which a breastfeeding mother nourishes a child who is not her own, inside privately arranged altruistic relationships with the other mother/s but apart from medical banking platforms (Falls 2017). Palmquist (2015) remarks

that wet-nursing, co-nursing and other forms of cooperative breastfeeding have a long history as popular practices, but that today the popularity – in the US – of certain webpages such as Eatsonfeets.org or HM4HB.net, set up as non-profit human milk sharing platforms, as well as other changes in the understanding of breastfeeding, are giving new life to these practices. In contrast to studies on informal human milk sharing in other countries – mostly in the US (Falls 2017; Palmquist, 2015) – in Spain there are no web pages or similar services that coordinate human milk sharing. Although wet-nursing was common in the past and forms of breast milk sharing may still occur, especially between close relatives, these situations appear to be more rare today. However, in our fieldwork in Madrid we have encountered a few informal arrangements, where some mothers, while breastfeeding their own child, provide their milk to friends or relatives who want to feed human milk to their infants but cannot breastfeed them temporarily – e.g. due to a medical surgery – or do not have enough milk for the baby's needs. In contrast with traditional wet-nursing, nowadays most milk sharing implies expressing milk and not actual breastfeeding. So, even in a transient, informal and non-standardized manner, informal milk sharing also implies biobanking practices. Samples are preserved at home in the fridge or freezer by the donor after expressing as well as by the recipient family who receives it. Even though safety measures to avoid contamination are mentioned in our interviews, informal milk sharing is officially and actively discouraged by the 12 de Octubre Milk Bank as potentially dangerous. This echoes medical discourses and wider controversies around new forms of human milk sharing: for instance, Carter et al. (2015) have studied recent representations in the US press of online peer milk sharing platforms, showing that whereas medically supervised milk banks are represented as safe, sharing milk is repeatedly characterized as dangerous, and mothers who resort to it are considered risky and imprudent.

A third practice around human milk banking moves us away from altruistic practices to other features of the bioeconomy: probiotic products that employ bacterial strains derived from human milk to treat mastitis in lactating women. Mastitis is a common and painful inflammation of a woman's breast during lactation caused by infection, due to a decompensation of mammary microbiota by the overpopulation of a commensal bacteria colony, or by the presence of a pathogenic agent – most commonly *Staphylococcus aureus*. Its symptoms include fever, pain, abscesses, and difficulties with breastfeeding. During the last fifteen years, a Spanish research team based at the Complutense University of Madrid – a public institution – and led by the microbiologist Juan Miguel Rodríguez has been working on mammary microbiota and mastitis physiology, as well as on new mastitis treatments with probiotics, produced out of various strains of lactobacilli isolated from human breast milk (e.g. Arroyo et al. 2010; Marín et al. 2017). Their first results were patented in 2004 (Pey et al. 2004) by *Biosearch Life* (previously *Puleva Biotech*), a Spanish

biopharmaceutical company connected to the dairy industry. After a successful clinical trial in human subjects (Arroyo et al. 2010), in January 2014 the company released a nutritional supplement named *Lactanza Hereditum* directed at breastfeeding mothers and advertised for the treatment of mastitis. Different clinical trials employing strains derived from Biosearch Life's patent can today be found in a variety of national health system registries, including those of Australia, the US, and the Netherlands. Increasingly, these probiotic products are extending their therapeutic aspirations beyond the actual treatment of mastitis to breastfeeding at large, by claiming to have preventive properties, benefits for the immune system and intestinal flora of both mother and child and even the capacity to improve infant colics. All of this informs us of an internationally emergent business based on the promises of probiotics derived from human milk.

The original bacterial strains used in *Biosearch Life* products were obtained from donated human breast milk. In the patent, the only background information given is that it came from a 35 year old woman. There are two practices of biobanking that take place here. The first has to do with the collection of tissues, microorganisms and cells: after being isolated, probiotic cell lines derived from that anonymous woman's milk were deposited at the CECT (*Colección Española de Cultivos Tipo*) in Valencia (Spain). Any company or researcher who wants to access those lactobacilli needs to get them from there. Along with hospital diagnostic collections, type culture collections can be considered one of the earliest forms of biobanks, with a particular orientation towards research in microbiology. Though most tissue collections are integrated into universities or public research centres, since the 1980s they have been developing ties with pharmaceutical and food industries (Taylor 2016). The second instance of milk banking and circulation happens in the laboratories and facilities of the pharmaceutical industry: through the process of drug manufacturing, samples of breast milk bacterial strains are transformed into valuable products which are commercialized as probiotic nutritional supplements.

4. Hybrid Zones and Care Assemblages in Milk Banking

Though these three forms of human milk biobanking – institutionalized banking in a public hospital institution; informal practices of peer sharing; and corporate logics of biomedical research and patenting of milk components – at first may appear to be completely different, there are, in fact, several points of intersection among them. In their re-examination of the narrative of public/private opposition in cord blood banking, Hauskeller and Beltrame (2016) focus on the proliferation of "hybrid zones", areas of institutional intersection between public and private cord

banks that, to some extent, are blurring the boundaries between these two cord blood regimes. Our aim is to extend this notion to all formal or informal practices and arrangements that generate logics of intersection, exchange or confusion between different forms of biobanking.

4.1 Circuits of Solidarity and Donation: Altruism as "Hybrid Zone"

In human milk banking, one of the easiest ways to find these "hybrid zones" is by focusing on donors' accounts. In our interviews with donor mothers, the distinction between formal donation, informal sharing among peers and donation to research is not clear-cut. The story of Laura[1], one of our interviewees, is illuminating in this respect.

As she recounts, after her first daughter was born, Laura got to know the 12 de Octubre HMB. When her own breastfeeding was established, she was willing to donate and phoned the bank to get some basic information about donor eligibility criteria – which she fulfilled – and procedures of extraction and donation. But she lived far away from the HMB, and having to take milk samples herself to the hospital ended up discouraging her. Some time after this aborted attempt at becoming a donor, and after Laura had a second daughter which she also breastfed, two close friends had twins. They were low weight newborns – especially one of them – and required a period of hospitalization, but they did not enter into the category of "very low birth weight", as they did not weigh less than 1500 g. So when the mother had problems expressing milk, they could not resort to obtaining milk from the bank. Convinced of the advantages of breastfeeding and wanting to feed their premature babies human milk instead of formula, they reached an informal arrangement with Laura in which she would altruistically express and collect her milk for them. She did this for the duration of the period they spent at the hospital – not 12 de Octubre but another public one – and three months after that. This practice of peer milk sharing, however, did not take place without the knowledge of the hospital staff. Laura and her two friends had a meeting with the hospital nurses where they were advised on safety procedures and provided with information on freezing, conservation, etc., in addition to being supplied with bottles and other materials for preservation and transportation. Laura continued giving milk to her friends for several months. But this was not the last experience she had with donating milk. Few months later, Laura received word, through a mobile group chat of recent mothers she participated in, of a nurse asking for voluntary donations to an experimental research project on the use of human milk for cancer treatment that was being conducted in Jaén, in the south of Spain. Apparently this nurse had a relative who could benefit from these experimental therapies. Laura and several other women from the group chat – some were also donors at 12 de Octubre – got in touch with the nurse and tried to organise how to proceed with the donations. In the end

the donations were not carried out, as there were some delays and specific instructions that did not arrive, but Laura remarks that she and the other mothers had been willing to donate. In her perspective, it was also an instance of helping others, even if it was less emotionally intense since it involved adults: "Maybe if it had been therapy for kids… Maybe we didn't put as much effort into it because it was for an adult. Being a breastfeeding mother yourself, it is like you feel more empathy for babies than for adults".

We can see in Laura's story the entanglement of different forms of biobanking. In Laura's experience, all forms of donation pertain to a similar altruistic impulse – to help others, to care for them. A mother who is willing to donate to the 12 de Octubre bank would also be open to other practices of donation – even if they are at different levels of "emotional distance", something which explains why Laura's donation to research never happened. As Palmquist affirms in her study of human milk sharing in the US: "donors often enter milk sharing after trying to donate to a milk bank" (2015, 40). We can also see how "circuits" of donor recruitment for different biobanking practices are mixed-up, intersect with each other – we could say that the mobile group chat where Laura got to know about the demand for donated milk for research is, in a way, a "hybrid zone" for donor recruitment. Drastic differences between donation for therapeutic use and to research or experimental therapies are also, to some extent, blurred from the perspective of donors. In the 12 de Octubre bank, in fact, there are currently several ongoing research projects which employ human milk samples. According to the coordinator of the bank, most donors are perfectly comfortable with some of their milk being used for research, even though they are constantly reminded of the scarcity of donated milk. Like in Laura's account, these other uses are probably less valued than the original one – helping extremely vulnerable newborns –, but not a single donor has apparently denied the bank's request for samples for research.

In the donors' accounts we can find a second instance of hybridity, concerning the mix of highly personal and more general motivations. Laura's experiences bring together different levels of emotional distance and personal involvement – from the more abstract ideas of helping premature babies or contributing to biomedical research to the direct involvement with her friends' babies. Even in donation to experimental therapies, as the example of the nurse demanding human milk for a direct relative demonstrates, there is a mix of perspectives, from the embodied and the personal to the abstract and general, which cannot be reduced to an impersonal idea of a "gift". Many qualitative studies of tissue donation also refer to this complex mix of identities, motivations and values attributed to donation for research biobanks. Locock and Boylan (2016, 806) indicate, for example, how willingness to donate, consideration of donations as "gifts" and other views on access to research results, commercial access, etc. vary depending on whether donors themselves have an illness which could benefit from the research. This is also evident in the fact that many donors to the 12 de Octubre bank, have personally

passed through the experience of having their babies in the NICU, something which symbolically enables them to understand the hypothetical position of a recipient's mother and to construct a sense of reciprocity, a sort of "hybrid altruism" where the differences between donating to strangers and helping relatives and friends are not so marked. In contrast to Titmuss's (1970) notion of altruism as a pure "gift to strangers", where its abstract forms of solidarity imply a clear demarcation between donors and recipients, human milk donation often mobilizes strong emotional identifications and symbolic shifts of the position of donor and recipient. In this respect, these donations are not so different to other collective practices of informal solidarity common among new parents. In these chains of reciprocity all kinds of objects circulate and are borrowed – baby clothes, cradles, carriers, breast pumps, wraps, slings, kangaroos, etc. This logic is quite clear in the following extract from the interview with Elena, a mother who became a donor to the HMB following several hospitalizations of her own son:

> We had to put Hugo [her son] in the hospital when he was just two days old… It was so hard. It still sends shivers down my spine. And I imagine myself in the shoes of other mothers who have a baby in the incubator and who can't provide enough milk. Being aware that breast milk helps them so much… So I thought: "If I can do something…". I'm not a doctor, there are few things I can do to help, but if I can contribute by giving milk… It is also an issue of solidarity among women. I think it is also *working for life*, caring for the creatures. There are sometimes babies who weigh a kilo, even less… (emphasis added).

4.2 Criss-crossing Institutional Boundaries

Apart from donors' experiences and motivations, we can also find "hybrid zones" in an institutional and organizational sense. Boundaries and distinctions between public banks, research networks and bioeconomic companies are traversed and re-configured by diverse lines of contact. The most obvious are the formal relationships established between the public 12 de Octubre HMB and other non-public institutions. Part of the funding for the bank comes from a non-profit, but private, organization, Fundación Aladina, that – even though its main focus is on pediatric oncological care – funded the remodelling and expansion of the bank's infrastructures in 2014. Research carried out at the bank also comes into contact with other public and private actors, and significantly, with the Complutense research team on the microbiota of human milk that made the original patent for Biosearch Life on breast milk probiotics. Research personnel, in fact, move between institutions: the full-time researcher currently employed at the 12 de Octubre HMB worked previously, and was trained, at *Probisearch*, the start-up company initiated by the Complutense team. As Hauskeller and Beltrame (2015) point out, hybrid zones also refer to the criss-crossing of different economic regimes – like market and redistributive economies.

Boundaries between therapeutic donation, research and pharma-industry are sometimes blurred here. Also, in the case of informal milk sharing, distinctions between medical and the non-medical are not completely clear-cut, as we could see in Laura's story. Not only because, as Palmquist writes, "milk sharing is not a rejection of biomedicine *per se* and in fact, a scientific evidence base often informs milk sharing decisions" (2015: 34) but, in Laura's experience, because of the direct assistance they found from hospital personnel.

4.3 Care Assemblages and Hybrid Kin

The donors' accounts also evoke another instance of hybridity that we consider relevant: the heterogeneous character of the networks that are formed around breast milk donation and the role care plays in bringing them together. Here we can speak of "care assemblages", where not only donors and recipients, but also many other actors, both human and non-human, are coordinated, as care, affectivity and interpersonal support are not only important in personal peer sharing relationships. Carroll (2015a) argues that breast milk donors to HMBs engage in a significant amount of *care work,* a form of unpaid, invisible labour, in order to follow the donation guidelines and thus be able to provide HMBs with the quantity of milk they need, as well as to comply with the strict safety measures. Our interviewees, accordingly, remarked upon the hard work implied in regularly expressing milk for donation – especially since they have their own babies to care for, and since safety requirements for milk donation are much stricter than those they apply when they express milk for their own children. Indeed, Elena specifically defined her involvement in milk donation as a form of "working for life", as we have seen, emphasizing both the caring involvement and the effort required by the procedure. Our informants commented on how they have to find a quiet moment in their day – moments that are hard to find for a recent mother – so they can express milk for the HMB. Specific organization and discipline are thus required to fulfil the rigorous protocols milk donation entails. Practices of donation are grounded in the everyday activity and micro-decisions of family life[2]. Support from partners, relatives and friends is essential – e.g. in helping to take samples to the hospital.

But care is not only an issue for donors and their families, but instead a rationale that involves all of the actors that intervene. For instance, bank personnel are very close with, friendly and supportive to donors, offering them help and advice if they have any problem with their own breastfeeding. Caring for donors is a way of assuring donations, but it is also part of the greater ideal of promoting breastfeeding and a more humane type of medical attention. Even technical aspects of the donation process are traversed by care and personal relationships. One example is the circulation of breast pumps: the HMB has a number of electric breast pumps that can be borrowed by donors, but usually donor mothers are

asked if they can find one themselves – for these are reserved for women who cannot afford to buy them or get one from acquaintances. According to the bank coordinator, most donors resort to their personal contacts to borrow one. As is typical with other baby paraphernalia such as clothes, breast pumps circulate among friends and relatives, embodying and strengthening, in a certain sense, those care assemblages which constitute an essential part of the social environment of donation.

A final topic regarding "hybrid zones" has to do with forms of symbolically constructing kinship through donation practices. There has been much sociological and anthropological literature on the transformation of traditional logics of kinship brought about by new medical and reproductive technologies (Strathern 1992; Franklin 2013). Catherine Waldby (2002b) characterizes different forms of bodily donation as forms of *intercorporeal sharing*, stressing their capacities of intensifying bonds between donors and receivers in sometimes unexpected ways. "Intercorporeal in the crucial double sense that [they involve] both a material confusion of bodies, a material indeterminacy and that [they make] a relationship – in this case, motherhood, fatherhood and kinship." (Waldby 2002b, 245). In the case of human milk biobanking, one can observe that these practices frequently generate symbolic bonds that surpass the mother-child dyad. Carroll indicates that milk donation "can stretch anonymously across vast geographic and spatial locales, and can even transcend the established kinship and community networks of the donor." (2015a, 177).

Our fieldwork also corroborates how human milk biobanking articulates emergent forms of surrogate, kin-like, relations, "hybrid kin" identities which are, in many cases, openly adopted by donors. Palmquist points out how non-profit donors in informal milk sharing webs are often referred to as "milk mothers", "milky mamas" or "sisters" (2015, 40) and Susan Falls starts her ethnography on milk sharing in the US by referring to the "milk siblings" her own son now has due to those practices (2017, xi). Our peer sharing interviewees employ this vocabulary of kin too: Laura refers to her friends' twins as her "milk sons". But kinship metaphors also appear in the public HMB, even explicitly – the book that donors receive as a gift from the bank at the end of their collaboration is titled *Hermanos de Leche* [*Milk brothers*] (Olza and Burgos 2011) [Image 1].

These symbolic forms of extended kinship, which bring together traditional and modern practices, can also be important for some technical protocols, becoming in itself performative of certain socio-technical ordering. We find a significant example of this in the 12 de Octubre NICU, where, unlike what happens in other milk banks and neonatology units worldwide (Cevese 2015), Muslim families are assured that the donated milk their children may receive comes only from mothers who are breastfeeding a child of the same sex, since traditional beliefs in some Muslim countries consider sexual intercourse between two adults that were "milk siblings" in the past to be incest. This protocol and the

heteronormative logic it implies are only possible because in the 12 de Octubre milk bank, in contrast to most milk banks in other countries, donated milk is not organized in pools of samples from different donors, but instead only samples from the same donor are pooled together. This procedure not only guarantees the highest degree of traceability, but it also allows for the samples to be distributed according to the specific characteristics and needs of the recipient babies.

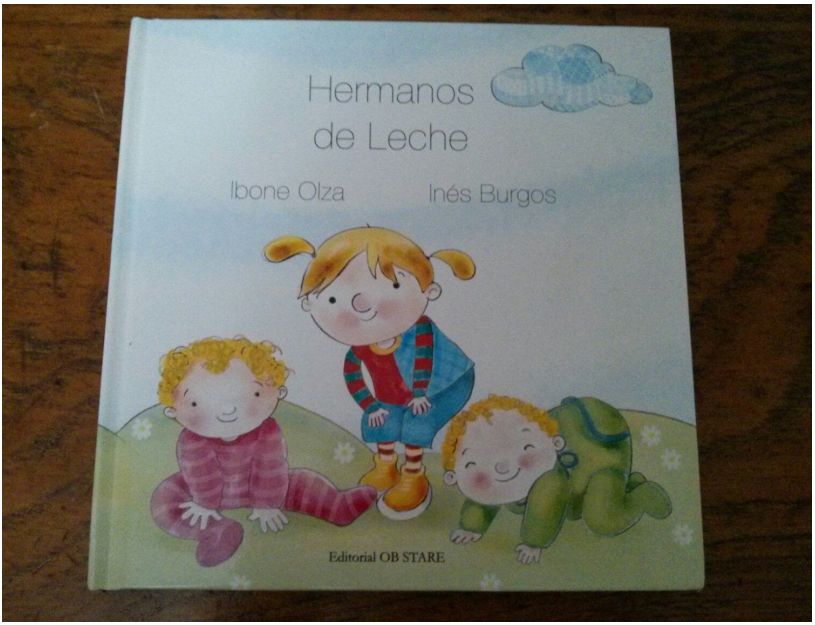

Fig. 1 – Book *Hermanos de Leche* [*Milk brothers*] (Olza and Burgos 2011). Present offered by the 12 de Octubre HMB to donors at the end of the donation process (photograph courtesy of one of our informants).

Whereas other banks that pool together samples from different donors provide a more homogeneous and standarized product, at the 12 de Octubre bank the preservation of the different samples offered by different donors becomes a useful resource to provide personalized prescriptions. Personalization also returns back to the donor, stressing the bond between donor and recipients: in the diploma that 12 de Octubre HMB gives to donors, a mother can find the exact number of babies who have received milk from her [Image 2].

Fig. 2 – Final diploma given by the 12 de Octubre HMB to donors at the end of the donation process (photograph courtesy of one of our informants).

It is important to note, finally, that this "hybrid kinship" is not without its ambiguities and displacements. Whereas traditional practices of human milk-sharing were based on direct breastfeeding of other infant/s, in HMBs human milk becomes a bio-objectified product that has been processed, one that comes in bottles. The set of lively relationships embedded in breastfeeding, a clear form of intercorporeal sharing (Waldby 2002b), is highly transformed in these practices.[3] Yet human milk remains a deeply charged corporeal fluid, symbolically and culturally. And while in current forms of milk-sharing there is no longer a direct bodily contact, as the milk is bottled and processed, and offered to the baby most commonly by their own progenitors or health professionals, symbolic conceptions linked to human milk seem to travel with the very milk. Donated human milk becomes a caring device, that in some way transports with it the donor mother and caring mothering. This can sometimes be a troubling and disruptive situation for mothers of recipient babies, as they may feel that their own mothering capacities and their mother-child bond are put into question. As Carroll (2015b, 12) notes "despite consenting to donor milk and expressing gratitude, many NICU mothers experienced great affective ambivalence associated with it being a bodily tissue and one with such profound socio-cultural connotations of reproduction and kinship".

5. Microbiota, Pasteurization and Boundaries: The Bio-Objectification of Human Milk

Though human milk biobanking practices are full of hybrid zones, the bio-objectification of milk requires purification and clarification, reduction of indeterminacy, an erection of boundaries. The process of bio-objectification refers to the mechanisms through which indeterminate body materials are stabilized (Vermeulen et al. 2012; Stephens and Dimond 2015). Bio-objectification is a necessary process for biobanking, which requires the coordination of a diverse set of devices. Political, socio-cultural and economic mechanisms of exchange; protocols, patents, standards and analyses; sterilizing procedures, surgical masks and caps, breast pumps, freezer packs, labels. All of these configure and sustain a concrete sociotechnical ordering which is repeatedly activated in its multiple entanglements, disentanglements and re-entanglements (Callon 1998). All of them participate in the construction of a distinctive bio-object (Stephens and Dimond 2015).

One way of approaching the process of bio-objectification is considering the operations of distinction, classification and purification involved in it (Bowker and Star 1999). There are many instances where this boundary work happens, both at a rhetorical level – discourses, metaphors – and at a material level, where "matter out of place" (Douglas 1966) is directly manipulated in the physical sense. The combination of both operations/levels results in a peculiar socio-technical ordering (Law 1994). In this section we will focus on a particular aspect of the process of bio-objectification of breastmilk: different forms of manipulation of bacteria and microbiological organisms naturally present in expressed milk. Preventing contamination is something that cuts across all discourses and practices involving human milk donation, either formal or informal. Set across the "intersection between *breastmilk-as-medicine* and *breastmilk-as-pollutant*" (Palmquist 2015, 30), there is quite a different treatment of microbial and bacterial milk components in each of the three practices we are analyzing, which results in different bio-objects. Human milk is, thus, a fluid bio-object sustained by the entanglements of relations it is inscribed in. Entanglements where bacteria are considered "virtuous", and deserve preservation and cultivation, or "wicked", pathogenic and dangerous, and prone to be eradicated. Quality and safety processes and risk discourses surround bacteria manipulation in all practices of human milk biobanking (Carroll 2014).

5.1 Human Milk Bank at the 12 de Octubre Hospital: "exquisite hygiene"

As Elena mentioned several times in her interview, milk donation at the HMB requires "exquisite hygiene". The quality manager of the bank described to us in great detail the procedures donated milk goes through

> prior to being offered to babies at the NICU, which echo the rigour and attention to security Caroll (2014) describes in her ethnography of two US HMB – although procedures described there are different. After completing a questionnaire to identify lifestyle habits and a blood test, donors are given all the required materials and taught how to properly clean their hands. Before each extraction, donors have to sterilize the breast pump and bottle and be sure to keep them sterile during the whole process of expressing. Milk is expressed with the donor wearing a mouth and hair cover. Once extraction is complete, the bottle is closed, labelled and directly stored in the freezer. Every 15 days bottles have to be carried to the HMB in a cooler bag with a freezing pack to avoid defrosting. Once there, donated milk is added to the database and stored in the raw milk freezers while awaiting pasteurization. The 12 de Octubre HMB follows the Holder method for pasteurization. First, raw milk bottles are defrosted through a controlled process, by introducing them into a bath at 40º C until they are defrosted at 50 percent, and completing the defrost in a refrigerator to keep the human milk properties at their maximum potential. Later, the raw milk bottles are correctly labelled and set into the pasteurizator, where they are processed at 62.5 ºC. In the middle of the machine there is a bottle of cow milk with a probe connected by a wire to a thermometer set outside. This is a security mechanism to guarantee that the temperature is homogeneous inside the pasteurizer. After thirty minutes, the pasteurized milk bottles are placed in another pasteurizer with crushed ice so that their temperature reduces to 4ºC in three to four minutes. Then the bottles are stored in the pasteurized milk freezers. This is the Brazilian HMB pasteurization model, and it is quite cheap and very efficient – around 95% of donated milk is successfully pasteurized. Yet it is quite labour intensive, as it requires a laboratory technician to control the whole process. After that, the milk is analysed so as to eliminate any contamination and sorted for NICU babies' consumption, matching the specific characteristics of the human milk samples with those of the recipients. (Notes taken from the first visit to the HMB in May 2017 and transcribed by the authors) [Images 3 and 4].

Exquisite hygiene, rigorous protocols and quality procedures with severe security controls eliminate all contamination risk and pathogenic bacteria (Carroll 2014). Banked human milk is a pasteurized and aseptic fluid, closer to a therapeutic device (Cevese 2015, 103) than to food. Yet this purification process does not come without its shadows, as the milk bank coordinator points out:

> Also, there is another big gap and that is that donated milk is never as good as milk from the mother herself, because it is processed. Pasteurization offers security, but it also entails some unwanted side effects: it eliminates pathogenic bacteria, but it also kills the intestinal flora that would colonize the newborn's intestine. And there is increasing scientific evidence on the importance of gut flora. In fact, we now provide probiotics to very low weight birth babies. [...] We are giving them Infloran©. It has two strains of lactobacilli [*Lactobacillus acidophilus, Lactobacillus biphidus*].

Fig. 3 – Donated human milk bottles at the pasteurizer following the Holder pasteurization protocol at 12 de Octubre HMB (photographed by the authors).

Fig. 4 – Storage and traceability of donated human milk samples at 12 de Octubre HMB (photographed by the authors).

Pasteurized "donated milk" appears in this discourse as a different bio-object than "milk from the mother herself". Another difference is constructed between "pathogenic bacteria" and "gut flora". Bio-objectification, here, takes place at a material as well as rhetorical level. The terms employed have connotations and motivate actions: we have to eliminate "pathogenic bacteria" but preserve or restore "gut flora". We have to promote breastfeeding from the mother herself, yet we provide pasteurized donors' milk in certain situations. 'Breastfeeding' becomes a contested term in and of itself. Does it refer to milk *originating in* the breast or directly *fed from* the breast? (Rasmussen et al. 2017). Most mothers at the NICU do not feed their babies with their breast, yet they often provide expressed breast milk in different quantities. Words are not elements separated from a given socio-technical ordering but rather an important aspect of it. Definitions and terminology are repeatedly used to reinforce boundaries between different types of biobanking. The HMB coordinator consistently referred to practices of informal human milk donation as "uncontrolled donations". The term places at the forefront the opposition between the rigour and control of HMB laboratory-pasteurized milk and the potential "risk" of raw milk shared informally, to which we now turn.

5.2 Informal Human Milk Sharing: Extending Symbiotic Relations

Issues of potential risks and potential benefits stretch in informal human milk sharing practices. In Laura's account, risks are equated with an indeterminate potential external contamination and not with the "raw" milk in itself, given that she keeps "good habits". Safety practices in this case emulate the HMB ones related to milk expressing, yet the level of detailed protocols and "exquisite higiene" mentioned by Elena is never reached. As Mary Douglas (1966) showed, pollution, contamination and risk are anthropologically related to what is considered "matter out place". Here, risk is contained by keeping expressed milk "in place": caring attention is given to the expressed milk and a significant effort is made to keep the "cold-chain". But there is also an aspect of everyday familiarity to this process that places it closer to other expressing practices by lactating mothers than to those of donors doing it for the HMB.

While they accepted Laura and her friends' decision to share milk informally, the hospital staff did also stress the risks involved for Laura and her friends. The milk would be raw and no pasteurization or analysis of the milk was going to be performed, so a certain threshold of uncertainty would remain. Discussing potential risks in milk sharing practices in the US, Palmquist (2015, 37-38) contrasts the ways risk is controlled in HMBs through informed consent, as opposed to what she identifies as "informed choice" in informal sharing.

Fig. 5 – Frozen human milk samples stored in a household refrigerator along with other frozen food supplies (photograph courtesy of one of our informants).

Boundary work is constructed here both rhetorically and materially. In the relationship between informal donors and recipients, unlike the detached safety of tested and pasteurized milk, trust and personal bonds emerge as relational sources of security. This has a material consequence: sharing goes beyond "human" milk, as human milk is never quite only "human": all the mammary microbiota of the donor's milk is shared as well. Palmquist (2015, 43) suggests that, in informal milk sharing, identities of donor and receiver are in a sense symbiotic. We can consider milk sharing as extending symbiotic relations beyond the human scale to engulf the microbiotic one: flora gut colonization in receivers' babies' may have the imprint of the donor, as each person develops a unique microbiota (Cacho et al. 2017). Extended forms of hybrid-kin and inter-corporeality open possible speculative futures here (Haraway 2016; Waldby 2002b).

5.3 Human Milk as a Source for Cultivating Bacteria

While human milk in HMBs is pasteurized, and in sharing practices it is kept raw, containing both the promise and risk of the ambivalent presence of uncontrolled gut flora, in the production of a probiotic nutritional supplement such as *Lactanza Hereditum*, raw human milk becomes a source for the cultivation of bacteria. This bio-objectification process depends on a different understanding of what human milk is "in

and of itself", an understanding which is based on the natural development of the human mammary microbiota. According to Bergmann et al. (2014, 1121), bacteria appear in the milk ducts during the last three months of pregnancy, with the concentration of bacteria reaching "a maximum during peripartum and then slowly decreases during the nursing period. During the weaning period, there is a sharp decrease in bacterial counts". Human breast milk is, thus, a live tissue inhabited by various strains of bacterial colonies that vary in quantity and composition throughout the breastfeeding process. Changes in this composition can imply an excessive proliferation that may become pathogenic or facilitate the incursion of pathogenic strains. The most common problems related to bacterial proliferation at the breasts are mastitis and obstructed ducts. We could argue that there is certain bacterial choreography, a certain dance in the human microbiota that promotes unstable equilibriums both in the mother's lactating body and in the breastfeeding baby, a relation very often referred to as symbiotic.

The production of the probiotic nutritional supplements based on the patent of Lactobacillus fermentum LC40 (CECT5716) and Lactobacillus salivarius (CECT5713) not only required donated human milk for the isolation of potentially beneficial strains. It also depended on more donated human milk, this time from the lactating mothers with mastitis who participated in the clinical trial and in several studies on the different responses of mastitis to antibiotic treatments and probiotics (Arroyo et. al., 2010; Marin et.al, 2017). Yet procedures to collect human milk samples for research and microbiota analysis entail a completely different procedure to the one proposed at the HMB. Arroyo et.al (2011) describe this procedure in detail, that was experienced by Carmen and described in her own autoethnographic notes[4]. Collection should take place two hours, at the earliest, after the last breastfeeding of the baby. Neither creams nor silicone nipple shields should be used, and if they are, the nipple and areola should be washed. Hands should be carefully washed as milk will be expressed manually, without the use of a breast-pump or associated device. Expressed milk should be collected in an aseptic container and handed in to the lab less than one hour later, at room temperature, or between one to twelve hours later if refrigerated. These samples are then cultivated in Baird-Parker Agar laboratory inverted plates and incubated at 35º to 37ºC in an aerobic atmosphere. Plate readings are performed at 24 and 48 hours (Arroyo et al. 2011). Human milk as bio-object is radically different in this procedure. Far from being an aseptic tissue, it becomes a sort of "primordial soup", involved in the production of magmatic and effervescent bacterial lives. Through the manipulation and ingestion of probiotic nutritional supplements, control over bacterial strain communities is expected, and therefore relief from breastfeeding illness and pains due to mastitis or obstructed ducts. Furthermore, the most recent research developed by the Complutense team and also by Biosearch Life is directed towards the use of probiotic nutritional supplements for

baby feed with formula to promote their own gut flora and to prevent infant colics (Bergmann et al. 2017).

5. Conclusions: Virtuous and Wicked Bacteria at Dance

Throughout the paper, we have surveyed the complexity surrounding human milk banking practices in Madrid. We started with the recognition that hospital milk banks are not the only form of biobanking, but that other practices, notably informal milk sharing and the manufacturing of certain probiotics, also involve forms of human milk banking. We then, proceeded to show the various hybrid zones between these three sets of practices, as can be analysed in donors' accounts, but also in institutional arrangements, heterogeneous care assemblages and symbolic constructions of "hybrid kin". The final section of the paper presented the forms of purification and technical manipulation of donated milk at play in each of the settings. If "purity" may at first seem to be more important in institutional biobanking practices and less so in other forms of milk sharing, our analysis suggests, on the contrary, that ideals of "purity" and "contamination" are present in every setting. That is to say, none of the assemblages can be thought without norms and boundaries that configure what are purity and pollution in each case. The 12 de Octubre Human Milk Bank purification process seeks to eliminate all potentially dangerous bacteria through "exquisite hygiene" requirements, and extremely rigorous processes of pasteurization, manipulation and traceability. At the lab, bacterial grown is favoured – yet only of those strains inhabiting the breasts – , both when producing probiotics or when analyzing human milk during mastitis. In informal human milk sharing, purity includes mutual trust, linking it to other "everyday" strategies for avoiding bacterial pollution. The different ways of manipulating bacteria and microbiota, thus, result in distinct processes of bio-objectification and generate different versions of human milk.

We could argue that what distinguishes and what unites these three forms of biobanking are bacteria manipulation, definition and treatment. Different processes of purification and bio-objectivization gain shape in concrete assemblages of bacteria colonies and human milk. Bacteria work as a boundary object that circulates and is diversely enacted in different social worlds, such as bio-banks, homes, labs, drug delivery plants, tissue collections, mothering networks, commercialized bio-materials, and in objects such as breast-pump devices, frozen human milk cristal bottles, containers, pasteurizers, samples, syringes. But mothering imperatives to care, construction of trust, emotional identifications, vulnerability, pain and joy are also involved. Far from being detached elements, all of these assemble and reassemble in concrete and recurrent doings, with bacteria running through them all, hybridizing yet differentiating the three sets of

bio-objectification processes. Depending on the particular definition and treatment it receives, microbiota can shift from being wicked and a dangerous pollutant to virtuous and potentially healing.

The practices of human milk donation and biobanking we have analysed here all entail forms of intercorporeal sharing (Waldby 2002b), intensifying bonds and creating ties of care and affect even when donors and receivers are unknown to each other. Those bonds and affects articulate some forms of "hybrid kin". Forms of kinship that sometimes take place symbolically, as with the book offered as a gift to HMB donors at the end of their donation. Other times they are articulated as caring assemblages, as in the case of Laura with her friends and their twins, where she extended her maternal role to others beyond her own children. And other times they manifest in deeply intercorporeal ways, yet overflowing the limits of the human, as in studies on the benefits of probiotics and mammary microbiota. This last aspect is perhaps the most promising one when thinking hybridity and kinship at once. Recent studies on personalization of donor breast milk with the live microbiota of the biological mother's own milk seek to extend the immunological properties of maternal breast milk microbiota to pasteurized donated human milk (Cacho et al. 2017). Yet, in doing so, they work to preserve the mother-child bond besides the donor milk consumption. We could understand, somehow, the inheritance of the mother microbiota as a biological extension of the self beyond the self. This same inheritance happens in informal milk sharing, as milk circulates raw: therefore, the microbiota of the donor mother can colonize the bowel of the baby who receives it. If the latest estimates of microbiota in humans bodies suggest that bacteria cells are as least as abundant as human cells in our bodies (Gilbert et al. 2018; Sender, Fuchs and Milo 2016), circulation and colonization of microbiota imply extended forms of intercorporality and bonds: bacteria sharing in itself configures certain forms of "hybrid kinship". Those ideas, and other recent research such as the Human Microbiome Project, lead us to reconsider limits and boundaries between individuals of different species, in a move closer to Haraway's reading of Lynn Margulis' holobiont figures (Haraway 2016). Bacteria become symbiotic entities, undetachable of ourselves, questioning even the very idea of "self".

These ideas may remain highly speculative, but what our study clearly shows is that, despite it sometimes being treated as sacred or valued, as "white gold" (Falls 2017) or "liquid gold" (Carroll 2014), human milk is never a "pure" and aseptic fluid, but instead a deeply hybrid and enmeshed one. A lively substance that not only changes according to the baby's needs or the mother's physiology, but also one that cannot be understood without addressing the colonies of bacterial life dwelling within it. Understanding the complexities of the circulation and biobanking of human milk requires that we pay special attention to the possible and impossible crossings of microbiota, and to how they draw boundaries and reshape human milk as a specific bio-object. In those crossings and circulations, in their

boundaries and regulations, a whole set of assemblages beyond the technical are re-enacted: identities, kinship ties, solidarity ties, and public and private arrangements. But also, in quite uncertain ways, the boundaries between the human and the non-human.

If we put hybridity and complexity at the forefront when studying biobanking, as we have tried to do throughout the article, a final question could be: how can we account for this "intimacy with strangers" (Haraway 2016, 60)?

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[1] Fictional name – all fragments of interviews have been anonymized.

[2] We would like to thank an anonymous reviewer for this clarification.

[3] We would like to thank the editors of the special issue, Lorenzo Beltrame and Christine Hauskeller, for their suggestion of developing this idea.

[4] Notes were taken in February 2014 after an acute mastitis when Carmen got in contact with Probisearch SL, a spin-off of the Complutense research group directed by Juan Miguel Rodriguez, to get her mammalian microbiota analyzed. She got to know about the group through the midwife in her public health local

centre. The midwife gave her Juan Miguel Rodríguez's email and introduced him as "the veterinarian of mastitis", telling her to get in contact with him as he offered women with mastitis probiotics to hail the infection. Two of the women we later interviewed also had this experience of accessing probiotics informally previous to its commercial distribution.