Big issues around a tiny Insect:

Discussing the release of Genetically Modified Mosquitoes (GMM) in

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Porque não viver?

Não viver esse mundo

Porque não viver?

Se não há outro mundo

Porque não viver?

Não viver outro mundo ...

Why not live?

Not live this world

Why not live?

If there is no other world

Why not live?

Not live another world ...

(Besta é Tu – Novos Baianos)

- Table of Contents -

- Illustrations -

- Introduction -

I have been asked why social scientists like me should turn her or his attention to matters of science and technology. “It is not social!”, my interrogator comments. I did not explain that scholars have long debated that technoscience is (socially/co-) constructed[1]; nor that some have advocated to (re)define the notion of social to mean association, and that we associate with science and technology (Latour, 2005; Tarde *apud* Vargas, 2007) . I gave the (not so) simple answer: “Because it is changing our lives”.

It is with that in mind that I set to write this thesis. The discussion over genetically modified organisms (GMO) and how it is transforming how we relate to nature, production, food, knowledge, safety, farming, etc. is extensive in and outside the academia. In this essay I will discuss a specific type of GMO, the genetically modified mosquito (GMM) *Aedes Aegypti*, particularly the releases that happened and are still happening in Brazil. Contrary to the general GMO topic, the transgenic mosquito has not received significant consideration, neither inside nor outside the academic walls. The attempt to document and discuss the GMM case study is then something new and innovative in itself because of the apparent lack of academic attention to this relevant issue for Science and Technology Studies (STS)[2]. This GM mosquito was developed as a solution to suppress the amount of dengue fever cases, a disease affecting millions around the world in tropical and subtropical areas. Brazil has

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[1] This list is long, but for some examples see Bijker, Hughes, & Pinch, 1987; Latour, 1987; Hacking, 1999; and Oudshoorn & Pinch, 2008.

[2] In fact, this statement might be wrong and it could turn out that other researchers have already published documented case studies on the GMM. However, it does not seem to be the case, at least for STS scholarly journals: several web engines were searched – in English and Portuguese – such as ScienceDirect, Sage Journals Online or Scielo, with keywords like “genetically modified mosquito”, “*Aedes aegytpi*” or “transgenic mosquito” – special attention was given to STS journals e.g. *Science, Technology and Human Values*, *Public Understanding of Science*, *Technology in Society*, *Social Studies of Science*, *Technological Forecasting and Social Change* — and no results were found.

worrying high and increasing number of cases and for decades has being trying to contain the disease. Oxitec, a British biotech company, has developed the OX513A, a GM *Aedes Aegypti*. They claim that with such a genetic modification the insects are sterile, when males are released into the environment and they mate with wild females, their progeny does not survive. As we will see, it is much more complicated than that. The relevance of this new development and how little it has been broadcasted, led me to focus on the case studied more than the theoretical discussion in the field. Actually, for the reasons outlined above, the thesis is constructed in such a way that the case study is at the heart of this analysis which, however, relies on sociology and STS concepts when relevant for our purpose.

Donna Haraway (1991) remembers us that the new relations of science and technology have transformed the sources of knowledge as well as of power. Thus, a new manner of doing analysis and political action is required (p.165) and that is what I will modestly attempt in the following pages. And to embody this essay, it is important to comment that, as a Brazilian, I turn myself at this case study, not only as a scholar but also as an interested (and worried) citizen.

In the first Chapter, *Once upon a time… : history of GMOs in Brazil*, I give an overview on genetically modified organisms in the country. I pinpoint its legislative framework and how it has been implemented (or not) in the case of GMOs. I also present how and by whom GMOs were introduced in the country. Afterwards, I describe the creation of 2005 Brazilian Biosafety Law, outlining the network of involved actors, how they performed and associated with each other. I also discuss how the genetically modified organisms were defined and presented in Brazil.

On Chapter 2, *The Genetically Modified Mosquito (GMM) case study*, I start by summarizing some facts about dengue fever: number of affected people in Brazil and in the world, information about the vector *Aedes Aegypti* and about the disease, how transmission happens, etc. Dengue has seen an increase on numbers in recent years and I highlight some possible reasons for why is that. In Brazil dengue is a serious health issue – it is the country with the highest number of cases reported to the World Health Organization (WHO). I discuss in what manner the country has been trying to "fight" the disease and I present a technique recently being tried out in Brazil: the case study of this essay, the genetically modified mosquito (GMM). I briefly describe how the transgenic mosquito, a living technology, works. Brazil was the third field trial in the world and, before focusing on the Brazilian case, I briefly present the first two – in Cayman Islands and Malaysia.

Chapter 3, *Same Same or Different?*, I introduce two distinct and somehow antagonistic principles for decision-making when it comes to dealing with new technologies, such as the GMOs and GMMs: the *principle of substantial equivalence* and the *precautionary principle*. The first bases itself on a comparison between the genetically modified organism and its traditional correspondent, considering that a GMO is not substantially different than its traditional counterpart (implying that both should be treated in the same way); the second prescribes that specific assessment should be done by considering the GMO as something new. It implies that GMO should be evaluated according to its interaction with the (specific) environment where it will be introduced. Subsequently I look upon the transgenic *Ae Aegypti* at the light of these two principles. I attempt to understand how the two approaches appear in the case study and which actors are promoting them.

On Chapter 4, *Risk and Uncertainty*, I turn to the discussion over risk and uncertainty. The concept of risk was made famous in sociology by the German sociologist Ulrich Beck, from the late 1980s onwards[3]. He introduces the idea that we are now living in a *risk society*, where we aim not only to increase technoeconomic development, but where the key point is

[3] Two other classical authors on the matter of risk are the British Anthony Giddens and the German Niklas Luhmann.

that our traditional modern institutions no longer seem to be adapted and relevant to deal with new risks and side effects caused by this very development. Nonetheless, the notion of risk would not be enough to describe our society. The definition of this concept is based on causal interpretations, only existing in terms of knowledge (scientific and non-scientific); risks are dangers that can be identified, can be *known*. The concept of *uncertainty* would better describe our situation. It can comprehend that science – or any other form of knowledge – cannot predict and describe all conceivable options, let alone the alternatives that for now are still unconceivable. Subsequently I analyze how risk and uncertainty appear in our case study, trying to display the different opinions about it.

On Chapter 5, *Beyond the Risks and the Uncertainties*, I propose to discuss other issues around transgenic mosquitos: interests, accountability, liability, public participation, and transperancy on the assessments. I also outline how the GMM, a *living technology*, can help us explore the relations and boundaries between culture/science and nature, and between technoscience and society. I also highlight the legitimating role of the 'idea of progres' and the social invisibility of risks. Finally, I discuss the political properties of any solution, focusing on the case of GMMs.

Methodology

To study and present the GMM case, I collected information from various sources: news (television, radio, newspapers, etc.), laws and regulations, scientific papers, open letters, different kind of reports, campaign videos and pamphlets, website information, memorandums, etc.

The original idea was to only focus on the Brazilian release. Nonetheless, during my research, I realized that there would not be enough material about this only case. I consider that this scarcity is itself a data worth mentioning. The legal process – usually slow in Brazil – has happened in an incredible fast manner, always with a positive outcome to GMM and sometimes in a sort of secretive way. The release of genetic modified mosquitos in the country has been very little publicized and discussed, either in the media or among politicians. For this reason, I have used data from the other two GMM releases – Cayman Island and Malaysia –, especially in Chapters 4 and 5 in order to look at the broader picture.

The media's portray of the GMM was also an interesting point for me. I investigated the releases as it was presented in Brazilian media. I tried to take into consideration only newspapers, magazines, TV programs, etc. with a significant number of followers or readers, i.e., the most known media sources in the country. Media is a main channel to communicate with citizens, and I was impressed on how little the case had been discussed. Analyzing their collection, I found out some of the most read sources in the country had not mention the genetic modified *Aedes aegytpi* at all[4]. On the cases where there was some broadcasting of the release, it was done mainly as a one-side story, a pro-GMM one. In Brazilian media the risks were superficially discussed. They presented it as a 'revolutionary' technological solution for such a problematic disease in the country, and Brazil was usually portrayed as vanguard for being one of the first to use it. To descript the other side(s) I also gathered news from international media – again trying to work with known ones.

The other sources were collected using mainly a snowball methodology. I started by doing a preliminary research around the topic. Then, to gather more material, I looked for the references mentioned on the text, and so on. This was specially the case for academic papers.

[4] Some examples are the well known *Carta Capital, Caros Amigos and Veja*. The first two are more left wing magazines, and the latter is a more right wing one.

Genetic modified mosquitos are something quite recent and not yet very discussed. In order to describe the controversy I "followed the actors"[5], trying to outline those involved. In the vocabulary used throughout this thesis, the reader will certainly (and rightly so) consider it as 'Actor-Network-Theory (ANT)-flavored' because I adopt concepts like spokesperson, enrollment, mobilization of allies, interessment, dissidence, sociotechnical networks, the nature/culture boundary, etc.

The literature in ANT offers a vast number of descriptive tools. For example, on the now classical article by Michel Callon (1986), *Some elements of a sociology of translation*[6]*: domestication of the scallops and the fishermen of St Brieuc Bay*, the French scholar proposes four 'moments' of translation: (1) problematisation; (2) interessement; (3) enrolment; (4) mobilisation[7]. Although I was inspired by these different categories, throughtout this thesis I did not focus specially on their distinction. Callon himself recognizes that these 'moments' are in reality never as distinct as he described on the paper (p.214). My emphasis was on how reality is a process, how "actor-network theory assumes that social structure is not a noun but a verb. Structure is not free-standing, like scaffolding on a building-site, but a site of struggle, a relational effect that recursively generates and reproduces itself" (Law, 1992, p. 5). Nonetheless, I need to precise that this thesis is not to be understood as an ANT research,

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[5] Since I was based in Maastricht and Liège when writing this thesis, I did not concretely follow the actors in their environment in Brasil, as an ANT-like ethnographic study would require. However, the information that I collected allowed me to somehow follow them and their trajectories as they moved about in academia, industry, civil society, policy-making circles, etc.

[6] Sociology of translation is an alternative name for Actor-Netwok-Theory.

[7] Callon (1986) defines that problematization "[determines] a set of actors and [defines] their identities in such a way as to establish themselves an obligatory passage point in the network of relationships they were building" (p. 201); "interessement is the group of actions by which an entity (...) attempts to impose and stabilize the identity of the other actors it defines through its problematization. Different devices are used to implement these actions" (p.203); enrollment "designates the device by which a set of interrelated roles is defined and attributed to actors who accept them. Interessement achieves enrolment if it is successful" (p. 205); mobilization renders "propositions credible and indisputable by forming alliances and acting as a unit of force" (p.209).

strictly speaking. Rather, this is a STS research inspired by ANT but not limited by nor designed for it.

As mentioned, as the research developed I realize the focus of this thesis should be the case study. I was also influenced by Actor-Network-Theory on the idea that there is a lot to be said just through description of a case: “good enquiries always produce a lot of new descriptions” (Latour, 2005, p. 146). I have also grounded my discussions on other STS concepts, such as Sheila Jasanoff’s *framing*, Donna Haraway’s *cyborg,* or Bruno Latour’s *hybrids*. I also attempted to bring into light some of the main scholars that deal with the topics of risk and uncertainty – e.g, Ulrick Beck, Michel Callon *et al*, Andy Stirling, etc. On the debate around genetically modified organism in Brazil I partially based my work on the analysis from Brazilian scholars, specially Letícia Maria da Costa da Nóbrega Cesarino and Renata Menasche – both of them anthropologists of science and technology.

- Chapter 1 - Once upon a time… : history of GMOs in Brazil

1.1 – Overview of Brazilian Legislation

The case study analyzed in this thesis will be the release of genetically modified mosquitos (GMM). However, it is worth having a closer look at some peculiarities of Brazilian context on genetically modified organisms, before we focus on it. The first GMO experiment performed in Brazil was in 1986. In that year, the Brazilian Agricultural Research Corporation (*Empresa Brasileira de Pesquisa Agropecuária* / EMBRAPA) – a research company linked to the Ministry of Agriculture, Livestock and Supply (*Ministério da Agricultura, Pecuária e Abastecimento*) – created the country's first genetically modified plant. The first transgenic animals were mice developed in 2001 by the University of São Paulo (USP) in cooperation with the Federal University of São Paulo (UNIFESP) (Cesarino, 2006, p. 77).

In 1995 the first attempt was made to define a specific legislation for GMOs. Nonetheless, Brazil already had some legal framework to deal with such issue. The 1988 Brazilian Constitution demands, in its Article 225, the presentation of a previous environmental impact study (EIA-RIMA) and also prescribes that it is the responsibility of Public Power to control activities entangling risk to life and the environment. The precautionary principle[8] became officially part of national legislation after the United Nations Conference on Environment and Development, which happened at Rio de Janeiro in 1992. The principle was adopted on the conference's declaration, signed at Rio on July 5, 1992, ratified by the Brazilian Congress on February 4, 1994, and implemented on the country on May 19, 1994.

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[8] In a few words it is the a idea or political tool that when in doubt or when there is scientific uncertainty regarding certain acts or substances, prudence will make the decision never fall to the detriment of nature. The precautionary principle will be addressed on Chapter 4.

A demand for precaution is also present in the Brazilian Legislation through law n° 9.605, from 1998, which deals with penal and administrative sanctions for conducts and activities harmful to the environment:

> Art. 54. To cause pollution of any kind at levels that result or may result in damage to human health, or cause the death of animals or significant destruction of flora: (…)
>
> § 3º - Incur on the same penalties prescribed above those who fail to adopt, when so required by a competent authority, precautionary measures against any risk of serious or irreversible environmental harm[9] (Brasil, 1998)[10].

Law n° 6.938 from August 31, 1981 – hence, even prior to the current Constitution – had created the National Council of the Environment (*Conselho Nacional do Meio Ambiente* / Conama), entity responsible for defining all national policies on environmental issues, and established the Brazilian Institute of Environment and Renewable Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* / IBAMA) – linked to the Environmental Ministry –, as the entity responsible for giving permission licenses to "effectively or potentially polluting activities" (Brasil, Lei Nº 6.938, 1981, pp. Art. 8º, I).

CONAMA's Resolution n°237, from 1997, reinforces that "enterprises and activities with significant environmental impact in the regional or national scope" (Brasil, 1997, p. Art. 4º) need IBAMA's environmental licensing. On annex 1 of this resolution, the activities that need permission from IBAMA are defined.

> Use of natural resources
>
> (…)
>
> - use of natural genetic heritage
>
> (…)

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[9] All laws, acts, resolutions, etc. from Brazilian legislation cited in this thesis are originally in Portuguese, and were freely translated by me.

[10] The reference to laws throughout the text was made according to the scale of it: national, state or municipal.

> - *introduction of exotic and/or genetically modified species*
>
> - use of biological diversity by the biotechnology [emphasis added] (Brasil, 1997).

Nonetheless, in 1995 Brazil formulated its first bill on biosafety. On the epigraphy it is stated that its goal was to regulate items II and V from the § 1st of the 225th article of the Federal Constitution:

> Art. 225. Everyone has the right to an ecologically balanced environment, a good for common use of the people and essential for a healthy quality of life; and it is imposed on the Public Power and the collectivity the duty to defend it and preserve it for the present and future generations.
>
> § 1º - To guarantee the effectiveness of this right, it is incumbency of the Public Power: (…)
>
> II – to preserve the diversity and integrity of the country's genetic heritage and inspect entities engaged in *research and manipulation of genetic material*. (…)
>
> V – to control the production, commercialization and use of techniques, methods and substances which involve risk to life, quality of life and the environment [emphasis added] (Brasil, 1988).

The 1995 Biosafety Bill (law n° 8.974) created a *technical* and permanent special commission. The National Technical Commission for Biosafety (*Comissão Técnica Nacional de Biossegurança* / CTNBio) – associated to the Ministry of Science and Technology – was assigned to define the safety of requests made to harvest and research genetically modified organisms (Cesarino, 2006, pp. 38-39). This law designated the commission's experts as the ones responsible for establishing the risk potential of GMOs in the country.

Hence, the establishment of CTNBio caused an overlapping of responsibilities around the matter of biosafety from genetically modified organisms in Brazil. There was a disagreement of who should be authorizing / prohibiting and regulating the research, harvesting and commercialization of GMOs in the country. In an ANT vocabulary we can say that there was a dispute of who should act as a spokesperson for GMOs in Brazil. To act as a spokesperson "can be described as the progressive mobilization of actors who render propositions credible and indisputable by forming alliances and acting as a unit of force. (…) [And a] controversy is all the manifestations by which the representativity of the spokesman is questioned, discussed, negotiated, rejected, etc" (Callon, 1986, pp. 209-210).

In the center of this dispute was the Monsanto patented[11] Roundup Ready soybean, also known as R.R.. At one side, IBAMA claimed that all matters that had environmental issues were its responsibility. It maintained the requirement for an EIA/RIMA and advocated a more precautionary approach. Two of the actors it mobilized to guarantee its position as spokesperson were law n° 6.938 and CONAMA's Resolution n° 237. It also mobilized some politicians – although these were not very formally organized as a group –, some national and international environmental organizations and consumers` protection groups. At the other side, CTNBio, allied by the 1995 Biosafety Bill, argued that it as the sole responsible for GMO related topics. It pushed for what they saw as less bureaucracy and a faster liberalization of transgenic. As it will be discussed in the following paragraphs, the proposal for a faster liberalization, interessed politicians linked to agro-business – a very well organized group with strong economic and political power – and many scientists and scientific organization[12]; and these became strong allies on the pro-GMO side. These actors mutually mobilized themselves as allies, since their goals and inclinations could be closely defined.

The Roundup Ready soybean brings in its structure the gene cp4 epsps – isolated from the Agrobacterium sp. estirpe cp4 – which makes it resistant to the glyphosate herbicide

[11] The patent from Monsanto of the Roundup Ready Soybeans is due to expire in 2014. In 2009 they already released in the USA a second-generation, the Genuity Roundup Ready 2 Yield (Monsanto, 2010?). In 2012, a new version will be launched targeting the Brazilian market: a genetically modified soybean which can tolerate the glyphosate herbicide, but which is also resistant to caterpillars common to tropical countries. In an interview Jesus Madrazo – director of Monsanto`s International Business Department– stated that "it's the first time the company develops a product for a specific country. *Brazil is the largest growing market for us*" (Gamez, 2010) [emphasis added].

[12] In April 2004, for example, thirteen "Brazilian scientific entities and organization" signed a letter to Senate claiming, "CTNBio should be the only and final instance with the legitimacy to judge the safety of these products" (Machado, 2004, p. 49).

Roundup, also patented and sold by Monsanto (Cesarino, 2006, pp. 40-41). Having the monopoly of seed and herbicide to which it is resistant, and demanding that those two are used together is a strategy of *tying*. Such practice is forbidden under Brazilian Consumer's Code, law n° 8.078, from September 11, 1990:

> Art. 39. It is prohibited to the suppliers of products and services, among other abusive practices:
>
> I – *to condition the supply of a product or service to the supply of another product or service*; and also without a cause impose quantity limits [emphasis added] (Brasil, Lei Nº 8.078, 1990).

It is also considered a crime against the rules of consumption, according to law n°8.137, from December 27 of 1990, which defines crimes against tax and economic order, and against consumer relations:

> Art. 5. Constitutes crime of the same nature [against the economic order]: (…)
>
> II – *to subordinate the sale of a good or use of a service to the acquisition of another good or use of certain service* [emphasis added] (Brasil, Lei Nº 8.137, 1990).

In 1997, CTNBio authorized field tests for research in transgenic soybeans (EMBRAPA, 2003). In June 1998, Monsanto requested from CTNBio permission to commercially harvest genetic modified soybean. As it will be address in Chapter 3, this request was made based on the substantial equivalence principle; i.e., a study made by Monsato compared the R.R. with a non-GM soybean and proved it was substantially equivalent. Since the traditional soybean had no associated risk, the Roundup Ready strain would neither. This was the first request for commercial scale of GMO; before, all demands were only for research and experimental cultivation (Menasche, 2005, p. 173; Menasche, 2000).

By request of Institute for Consumers Defense (*Instituto de Defesa do Consumidor* / IDEC) and Greenpeace, the *11ª Vara da Justiça Federal* (11ª Court of Federal Justice) conceded a positive preliminary injunction prohibiting the Union to authorize the commercial harvest before conducting EIA-RIMA and properly regulating the issues around GMOs (EMBRAPA, 2003). The argument presented by IDEC and Greenpeace was the unconstitutionality of 1995 Biosafety Bill, which left a gap of doubt in Brazilian legislation.

Nonetheless, CTNBio issued a positive assent[13] on the request to plant R.R. soybeans at a commercial scale, declaring that it did not represent a risk to the environment nor to food biosafety. The preliminary injunction from 11ª Court was overthrown in November 1998. The cultivation of genetically modified soybeans was authorized, as long as quarterly reports about quality were presented and that the segregation between GMOs and non-GMOs would be established. CTNBio kept alleging that environmental impacts study / report was not necessary (Menasche, 2000).

In February 1999, IBAMA, together with IDEC and Greenpeace, submitted a public civil action demanding the performance of an EIA-RIMA before authorizing GMOs' commercial use in Brazil (EMBRAPA, 2003; Menasche, 2000). In June, another preliminary injunction was given in favor of an EIA-RIMA requirement before authorizing the R.R. soybeans in commercial scale; this time the injunction was issued by the *6ª Vara da Justiça Federal* (6ª Court of Federal Justice) (Cesarino, 2006, p. 41). In July, Monsanto requested from the *Tribunal Regional Federal* (Federal Regional Court / TRF) suspension of the injunction blocking the approval for cultivation and commerce of the transgenic soybeans. Nonetheless, the TRF's president rejected Monsanto's demand (Menasche, 2000).

While this war of preliminary injunctions took place in Brasília, the use of R.R. soybeans grew in the country. Starting around 1999, they were illegally smuggled from Argentina into the country through the southern state of Rio Grande do Sul (RS) – thus acquiring the nickname 'Maradona soybeans' (Cesarino, 2006, p. 42; Vara, 2004, p. 102). Many authors

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[13] Thirteen of the fifteen present members voted for allowing the cultivation. The consumer's representative voted against it and the one from the Ministry of International Relations abstained (Menasche, 2000).

(Taglialegna & Carvalho, 2005; EMBRAPA, 2003; Cesarino, 2006, pp. 41-42) highlight economic gain as the main motivation for why farmers decided to adopt clandestine seeds. Especially, since R.R. soybean was illegal in Brazil at this time, the farmers did not have to pay Monsanto's royalties. Nevertheless, a report from EMBRAPA stated that:

> Notwithstanding, many farmers also suffered losses; since the seeds were not adapted to Brazilian soil, they presented productivity problems caused by failures in germination, plant stunting, among others. In addition to these problems, farmers that commit this misdemeanor are endangering the health of crops, since smuggling can carry diseases eradicated or under control in a given region (EMBRAPA, 2003).

Renata Menasche, who did ethnographic work among the *gaúcho* – demonym for those from RS state – farmers, also pinpoints peer pressure as a reason for adopting GM seeds. According to them, there was a strong pressure from the pro-GMOs rural leaders such as the Farsul (Agriculture Federation from Rio Grande do Sul/ *Federação da Agricultura do Rio Grande do Sul*) (Menasche, 2003, pp. 72; 216; 242-251; 2005, pp. 175-177). Furthermore, Menasche also identifies among the farmers what she defines as an *inverted work ethics*: the use of R.R. presented an opportunity to reduce the amount of work needed to control the weeds (2003, pp. 143-144; 151).

In 1999, Olívio Dutra, from PT (*Partido dos Trabalhadores/* Workers Party), became governor of Rio Grande do Sul. He announced as a goal to make the RS a *transgenic free zone* (Silveira & Almeida, 2005, p. 75). In March, he signed the decree n° 39.314 which declared that the public power from RS must be notified of areas where GMOs are being harvested. This decree also defines an EIA-RIMA as a mandatory precondition to experiments with GMOs. Based on this decree, the Secretary of Agriculture and Supply (*Secretaria de Agricultura e Abastecimento*) from RS interdicted fields of experimental transgenic cultivation; even those that already had been authorized by the CTNBio, but had not conducted an EIA-RIMA (Menasche, 2005, p. 174). In October 1999, state inspectors started to collect seeds samples throughout the RS to conduct transgenic tests. The *gaúcho* rural producers harvesting genetically modified soybeans would have their entire crop apprehended. Nonetheless, in November and December hundreds of farmers organized themselves against the inspections[14]. They blocked roads and kept the inspectors as hostages (p. 175). Under these circumstances, the state government retreated and inspections were cancelled.

Insofar the RS government was trying to make a strong stand against the GMOs, at national scale the dominant approach was to turn a blind eye to the soybeans illegality. The Union established legal *ad hoc* devices to maintain the GMOs.

In the beginning of his mandate, the President Luiz Inácio 'Lula' da Silva (PT), established through decree an inter-ministerial commission[15] to tackle the issue of transgenic. Before the commission had reached any conclusion – even though the R.R. soybeans were still banned in the country –, the national government issued two provisional acts (MPs / *medidas provisórias*)[16] to temporarily validate the status of GM soybeans in the country. Overruling all former laws and decrees that forbade transgenic in Brazil, in March 2003 Lula signed the MP n° 113/03, which allowed commercialization of the 2002/2003 genetically modified crop. In September 2003, MP n° 131/03 was signed by the Vice-President José Alencar (PRB) – at

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[14] The leftist orientation of the governor and his strong connections with social movements that demand an agrarian reform – i.e., a reorganization of the land structure and ownership in order to promote a redistribution of it – contributed to the farmer's reaction. They argued the inspections were land invasions, and a strategy from the state government to force the soybean farmers to vacate their land (Castro, 2006, p. 34).

15 The inter-ministerial commission was headed by the Chief of Staff (*Casa Civil* – highest-ranking member of the Executive Office – with representatives from the Secretariat of Food Security and Fight against Hunger (*Secretaria da Segurança Alimentar e Combate à* Fome); and from the Ministries of Agriculture, Livestock and Supply (MAPA); Science and Technology (MCT); Agrarian Development (MDA); Development, Industry and Foreign Trade (MDICE); Environment (MMA); Justice (MJ); and Health (MS) (Cesarino, 2006, pp. 36-37).

[16] In Brazilian constitutional law, a Provisional Act (MP) is a unilateral act signed by the President, with the force of a law and with no participation from the Legislative Power. The premise of a MP is urgency and importance, cumulatively (Silva, 2007). It was 'imported' from the Italian model: the *provvedimento provvisorio*. Nonetheless, in Italy, if the Prime Ministry issues a provisional act, on cases of urgency and importance, it comes with a responsibility: if the provisional act is not approved by Parliament within 30 days, the Prime Ministry can be overthrown by a simple vote of mistrust. Meanwhile, in Brazil it has to be approved by Congress within 120 days (60 days which can be extended for 60 days more), and if it is not approved nor a decree is made to regulate the effects of the MP, nothing happens (BARROS, 2000).

the time, acting President – authorizing farmers to plant the genetically modified seeds which they had stocked prior to this act. Although selling the crop and planting GM soybeans was momentarily permitted, buying and selling the *seed* was still consider prohibited (Brasil, 2003, pp. Art.1, § 2). In October 2004 another provisional act was issued: the MP n° 223/04 allowed once more farmers to use genetically modified soybean seeds and to sell their GM crop. Nonetheless, buying / selling the seeds was still consider an illegal activity in the country. The national government justified the MPs that legalized the clandestine crops as the only way to prevent a damage estimated to be above one billion dollars (Cesarino, 2006, p. 42)[17]. Furthermore, the southern farmers strongly lobbied for the decriminalization of their genetically modified crops. They declared that that those were the only seeds they possessed, and to avoid losses they threatened to carry out the planting even if it would be in a clandestine way (Barboza, 2004, p. 438). Despite its juridical vagueness, R.R. seeds spread from RS to the rest of the country, starting with the nearby state Paraná[18] (Cesarino, 2006, p. 42). Ana María Vara (2004) also comments the effect Brazil's 'authorization' had in the international debate around transgenic, and more specifically in Argentina. While the 'no' declared by European consumers had tilted the balance towards a negative attitude regarding the adoption of GMOs, the 'yes' issued by Brazilian farmers (and executive power) switched the balance to a more positive approach (p. 102, p.122).

Victor Pelaez (2007) writes about how the Brazilian regulatory framework around the GMO was governed not by pre-established rules, but by exception regimes. I.e., "the already existing regulation was systematically disregarded in name of a governability (*governabilidade*) aimed to meet the urgent commercial interests of biotechnology

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[17] It is estimated that 70% of the 2002/03 crop from the RS farmers were GMOs, which would represent 8,4 million tons of soybeans (EMBRAPA, 2003).

[18] Paraná is the second largest producer of soybeans in the country. The first transgenic farm was found in the crop of 2001/02, at the region of Toledo, southwest of the state (EMBRAPA, 2003).

companies" (p. 14) and Brazilian rural producers. In 2005 a new Biosafety Law was established, and, as we will discuss, after several months of debates and disputes, those same interests managed to prevail.

1.2 – Brazilian Biosafety Law of 2005, or how GMOs were framed in Brazil

In the inter-ministerial commission set by President Lula in February 2003, there was a clear division: at one side the Ministries of Agriculture (MAPA), Development (MDICE), and Science and Technology (MCT) pushing for a faster liberalization of GMOs; at the other side, the Ministries of Environment (MMA); Health (MS) and the Agrarian Development (MDA) (Cesarino, 2006, pp. 36-37) demanding a more precautionary approach. Despite disagreements, in October of the same year they had developed a bill to be presented in Congress.

Letícia Maria Costa da Nóbrega Cesarino (2006) wrote at length about the numerous steps the bill passed before becoming a law. Gustavo Henrique Fideles Taglialegna and Paulo Afonso Francisco de Carvalho (2005) also analyzed the construction of this bill, focusing on the lobby made by different pressure groups. Here I will only pinpoint some aspects of the biosafety bill, which I think are paramount to understand how GMOs were and are perceived and defined in Brazil.

First, it is important to highlight that the Brazilian Biosafety Bill dealt not only with the issue of genetically modified organisms, but also with the stem cells research. This fact had a strong impact on how transgenic organisms were *framed* in Brazil.

Sheila Jasanoff (20005) presents the concept of *framing* in her book *Designs of Nature: Science and Democracy in Europe and the United States* where she compares the different ways biotechnology was dealt with in Germany, Britain and USA. On this book she set to analyze how biotechnology was framed for public action in these three countries. For her this concept:

> implicitly makes room for the contingency of social responses and the partiality of the imaginative space that is carved out for political action in any society. (…) Selectivity is inevitable in the construction of frames, but so too (…) is cultural conditioning. Framing in this way occupies a middle ground between the contingent and the determined (p. 25)

In other words, framing means how a certain issue is constructed, organized, presented, and dealt with. What elements are highlighted and which are left in the background. It is how a community makes sense of their experiences, the "principles of selection, emphasis and presentation" (Pavone, Goven, & Guarino, 2011, p. 2), and based on this, how they decide to take political action. In this sense, Jasanoff (2005) explains

> the regulation of science and technology, whether to further innovation or control risk, can fruitfully be seen as a kind of story-telling by communities situated in particular times and places who are attempting to deal with unsettling or disruptive changes in their environments (p. 23).

We must have in mind that the entire 'Brazilian society' did not frame GMOs homogenously. A critic one might do to Jasanoff's book is that one might think she portrays as if everyone in the USA, Britain and Germany framed biotechnology in the same way – differently among the three countries, but alike internally. Nonetheless, what I think she wants to underline is that in all these societies, there was a dominant way, which managed to prevail. What we see in the following pages is how a specific way of framing emerges due to the construction of a certain sociotechnical network.

Hence, a key point to this controversy is that in the 2005 Biosafety Law, stem cells and GMOs were being dealt together. This association acted in the network and created a series of new connections. Remembering here that agencies can be (re)defined to all "accounts as *doing* something, that is, making some difference to a state of affairs, transforming some As into Bs through trials with Cs" (Latour, 2005, pp. 52-53). One association that emerges is the collaboration between those pro-GMOs and those who urged for the liberalization of stem cells research. Since they had common interests, one mobilized the other as an ally. Sometimes they acted as one group, some other times as two distinct groups who supported each other. As Latour (2005) reminds us, groups exist as they are performed, "made by the various ways and manners in which they are said to exist" (p. 34). This mutual translation, that allowed them to act as one large and powerful group sometimes and as two different groups when needed resulted in an even stronger political power.

It was common in their arguments to mobilize historical events as allies, to illustrate how sometimes scientific development is not 'well understood' or it is even punished. They enrolled, for example, Galileu Galilei and his incrimination by the Church in 17th century – the most used example. Very frequently mentioned was also the Brazilian example of Oswaldo Cruz and the Vaccine Revolt[19], which happened in Rio de Janeiro, 1904 (Cesarino, 2006, p. 179).

During one of the debates about the bill, in December 4, 2003, Francisco Aragão from EMBRAPA (a pro-GMO entity) stated:

> In 1788, Edward Jenner was criticized by society, including the scientific community, for seeking to develop a smallpox vaccine. The same thing happened to Oswaldo Cruz (…). Public opinion is important, but research must continue because context changes ... We have to think ahead and not on immediate issues.
>
> In science, there are many discussions, especially at the borders, which will latter on settle. There is, in my house, a library with some books that I call 'the burnt books': The Dialogue of Galileo, and The Origin of Species by Charles Darwin. But even if these books were burned, the ideas have prevailed. We know that ideas ultimately prevail (*apud* Cesarino, 2006, p. 179).

Relating the case of GMOs and stem cells with historical events where science was "misunderstood", was their way of constructing and presenting the issue, i.e., of framing

[19] Popular uprising which occurred as a reaction to the attempt from Oswaldo Cruz, then General Director of Public Health to impose mandatory, universal vaccination against smallpox.

transgenic organisms and stem cells. The group pro-GMOs *chose* – choice not necessarily in the sense of manipulating, but in the sense that but it was the story-telling strategy favored by pro-GMOs actors – to relate transgenic organisms and stem cells with scientific and technological progress. It is here that the pro-GMOs actors mobilize one of their strongest allies: the 'idea of progress'.

On October 06, 2004, during the final voting at the Plenary Session, two addresses demonstrate how the 'idea of progress' was mobilized, constructing a certain framing of GMOs in the country[20]. The first speech was from Senator Antonio Carlos Valadares, from the PSB (Brazilian Socialist Party / *Partido Socialista Brasileiro*) of Sergipe:

> If it was not for the great leaders who undertook the changes in our world, confronting the forces of backwardness, we would not have electric energy, nor steam-powered engine, nor the facilities that are created by the developed world, through technology advances that were the fruit of strenuous struggles, including the risk of life, from people like Galileo and many others who have faced ponderable forces who manipulated public opinion and society (*apud* Cesarino, 2006, p. 183).

Senator Juvêncio da Fonseca, from the PDT (Democratic Labor Party / *Partido Democrático Trabalhista*) of Mato Grosso do Sul, also stated:

> It was said that, at the international level, this [the GMOs] is an topic still not very clear, but I think it is of a meridian clarity. The whole world is in search of enhancements on biotechnology to improve production and increase productivity… *There are those who wish for caution. Why? So the whole world can advance and Brazil is left behind?* (*apud* Cesarino, 2006, pp. 183-184) [emphasis added].

The GMOs – together with the stem cells – were being framed as an answer to take Brazil out of the backwardness and put in the path of progress, of development. A comic published at the *Zero Hora*, a newspaper from Porto Alegre, RS, illustrates this idea:

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[20] The strong influence of Comte's positivistic ideas can be observed in the country. The Brazilian flag has part of the positivist motto on it: Order and Progress – Love was left out. Two of the three Positivist Churches (the third is in Paris) are located in Brazil (Igreja Positivista do Brasil, n.d.). However, to make any concrete statements further research is needed.

Figure 1 - Comic about GMOs - published at Zero Hora[21], 27/06/2003

On it the woman is saying "You must be kidding!"; and the man answers "It's true! ... There are people who don't eat transgenic". The comic constructs and presents the matter of transgenic organisms, especially in the case of food, in such a way that it already insinuates how we should tackle it. It links the GMOs as a solution to confront one of Brazil's biggest social issues: hunger; thus, mobilizing another strong ally. By doing so, it can points a finger towards those against transgenic, as if they do not want the country to develop, or do not see that the country has more important issues that must be dealt with.

Furthermore, the stem cells, which started as a secondary issue on the Biosafety Bill, got more and more attention from public opinion. On the day the project was going to be voted in the House of Representatives (*Câmara dos Deputados*)[22], several people, including children,

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[21] Zero Hora is one of the most popular newspapers in Porto Alegre, capital of the Rio Grande do Sul state.

[22] This was the second time the project passed on the House of Representatives, and after this, it would became a law

who suffered from degenerative diseases were present. They had come to pressure the parliamentarians, as well as gain the public opinion on the case of research on stem cells. While the project was being discussed it was common to see in the media news about the advantages of the potential benefits of embryonic stem cell research (Taglialegna & Carvalho, 2005, pp. 16-17). The issue of GMOs was left on the background and "took a ride" (Dolabella, Araujo, & Faria, 2005, p. 73) at the liberation for stem cells research. If we go back to our ANT vocabulary, we can see how once the again the link between stem cells with GMOs created a new association. Due to this connection, transgenic could more easily define themselves within the scientific developments that should not be stopped by those *outside* science; in the case of stem cells the religious people, and for the genetically modified organisms (mainly) the environmentalists.

Under this context, a new association emerged. Those against GMOs or those in favor of a more precaution-oriented approach towards transgenic enrolled the *bancada evangélica,* fiercest supporters for the ban on stem cells researches. The *bancada evangélica* is the informal organization of evangelical parliamentarians whose lobbying power has grew enormously in recent years[23]. Those against GMOs decided to back up banishing stem-cell research in exchange of the support from the *bancada evangélica* on the matter of genetically modified organisms (Taglialegna & Carvalho, 2005, p. 18). Although this mutual translation gave both groups some maneuver for lobbying, they were not as strong as the link between those who pressed for pro-GMOs and of those for liberalization of stem cell research. Their interessment was not as successful, both sides resisted enrollments.

[23] Rafael Bruno Gonçalves (2010) wrote an intersing paper on how religion (having in mind the evangelicals) have became an important source of political recruitment and political identity in Brazil. He highlights that between 2003 and 2006 seventy evangelical parlamentarians were elected in the country.

By highlighting the association between environmentalists and religious people, those who praised for faster liberation of transgenic and stem cell research could more easily define them as the forces outside science that attempt to hold back scientific development – a “subtle control of the opponents movements” (Latour, 2005, p. 96). At the same time that those in favor of a precautionary approach towards GMOs gained political power by linking themselves with the evangelicals, they lost some of their legitimacy to act as spokesperson for GMOs because of the manner they were redefined.

On the side of the pro-liberalization, the organization of parliamentarians tended to be around the *bancada ruralista*, composed by the large rural producers. The *bancada ruralista* represents one of the strongest lobbying groups in Brasília; in 2003 they were 103 representatives and 5 senates, the largest of the *bancadas* (Cesarino, 2006, p. 82). Additionally, there was the support from the lobby of biotechnology companies and many scientists and scientific organizations, which are strong allies.

Another point that should be mentioned when describing how GMOs were framed in Brazil is the discussion around the separation between science and politics. In the 2005 Brazilian Biosafety Law these two spheres are seen as two distinguish entities. The law established CTNBio with complete autonomy to decide the risk potential of genetically modified organisms. It is linked to the Ministry of Science and Technology; and, as the name declares, it is a *technical* commission. The website states is purpose is to:

> provide *technical* support and advisory assistance to the Federal Government in the formulation, updating and implementation of the National Biosafety Policy on GMOs, as well as establishing the *technical* safety standards and *technical* advice concerning the protection of human health, living organisms and the environment, for activities involving the construction, experimentation, growing, handling, transport, marketing, consumption, storage, release and disposal of GMOs and derived products (CTNBio, n.d.) [emphasis added].

Nonetheless, the law created another commission, the only one with power to overrule the decision from CTNBio. When dealing with GMO release for *commercial scale* only, the National Biosafety Council (*Conselho Nacional de Biossegurança* / CNBS) could appeal to the decisions made by CTNBio. This Council is composed by eleven Ministers and would represent the political sphere. Its function is to analyze the request for transgenic releases "with respect to aspects of socioeconomic convenience and opportunity and national interest[24]" (Machado, 2004, p. 48).

This *choice* of trying to separate between the technical sphere and the political one had and has important consequences on the framing of GMOs. It implies that there is a distinction between scientific matters and political/social ones; it also implies that there are those who are responsible for the former – scientists – and those who should deal with the latter – politicians. It imposes a separation between society and science. We will discuss again this matter on Chapter 5; however, we should have in mind that it was the pro-GMOs group that pressured for this kind of division. For example, Senator Osmar Dias from the PDT of Paraná – one of the five parliamentarians designated to elaborate the Biosafety Bill, and himself a member of the *bancada ruralista* – argued that:

> To defend national sovereignty, I made sure to put, in my report, two spheres of decision-making: one *technical* and one *political*. The technical is CTNBio, for which to be part of it one needs to have a PhD, be a specialist in various fields of knowledge. It cannot be a politician. Among the responsibilities of the CTNBio is not the issue of sovereignty, but the technical, scientific matter. The issue of sovereignty is in the National Biosafety Council... The Council will ensure that decisions are made to defend the fatherland, the national sovereignty. The only difference between these two councils is that one has to be made up of technicians and the other by politicians. The two are there with their responsibilities very well defined (*apud* Cesarino, 2006, p. 61) [emphasis added].

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[24] The concept of *national interest* is not very precisely defined. For Paulo Affonso Leme Machado it "encompasses a huge number of interests involved in the issue, such as those on environment, health and biosecurity. In the sphere of socio-economy are employment, agricultural production, trade and national levels" (Machado, 2004, p.48).

Finally, one last comment should be made about the political situation. Before getting into power with Lula, the Workers Party (PT) used to assume a position against the release of genetically modified organisms. Nonetheless the party became divided once it became the government[25]. In an interview to a TV show on August 17, 2003, the President, when asked about GMOs stated that "politically I was once very much against it; today, scientifically, I have my doubts" (Cesarino, 2006, p. 47).

[25] Marina Silva was the most prominent member of the PT to defend a more pro-precaution approach. She was the Minister of Agriculture at the time, and one of the politicians with strongest lobbying power. Later, in protest against the environmental policies endorsed by the PT, she left the party and joined the PV (Green Party / *Partido Verde*). She launched her candidacy for the 2010 President election, receiving almost 20% of the votes.

Chapter 2 - The Genetically Modified Mosquito (GMM) case study -

2.1 – Dengue Fever in the country

Dengue is a tropical/subtropical disease caused by the most common arbovirus (arthropod-borne virus) and 2.5 billion people live in areas where the disease occurs[26] (World Health Organization, 2009). "It is estimated that every year from 50 to 80 million people are infected by it, in 100 countries; approximately 550,000 of these people require hospital care and at least 20,000 die"[27] (Mendonça, Souza, & Dutra, 2009, pp. 257, 264-265).

Brazil is the country with the highest number of dengue cases reported to the World Health Organization (WHO). Between 2000 and 2005, 3.5 million people reported being infected. This number represents 78% of the cases reported in the Americas (approximately 4.5 million) and 61% in the world (approximately 5.7 million) (Roriz-Cruz *et al*, 2010). A research made in 2007 showed that this tropical disease was present on *all* 27 states of the Union, among 3,794 municipalities (Câmara *et al*, 2007, p. 192). Although cases are reported spread throughout the country, some regions have a worse situation. The Northeast has the highest amount, with 48,3% of the cases, followed by the Southeast region with 37,2%; together they represent 85,5% of the dengue cases in the country. The other regions have much lower numbers: Center-West has 7,6%, North 5,7% and South 1,2% (p. 193)[28]. Dengue costs an estimated amount of one billion reais –approximately 400 million euros – annually to the public funds (Ministério da Saúde, n.d. b).

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[26] Dengue is considered one of the seventeen Neglected Tropical Diseases (NTDs), the most common afflictions of those who find themselves among poorest people in the world (World Health Organization , 2011) .

[27] The number of death due to dengue is three times higher than what influenza A H1N1 killed in 2009 (Roriz-Cruz, et al. 2010).

[28] One of the worst numbers came from Rio de Janeiro State (located in the Southeast region); during the first semester of 2011, 142,147 cases and 107 deaths caused by dengue were reported (Fundação Fiocruz, 2011).

The mosquito *Aedes aegytpi* is the main vector for dengue – in Brazil transmission by *Ae.* aegytpi is the only acknowledged mean of infection[29]. It can also be the vector for avian malaria and yellow fever viruses (Wilke *et al*, 2009, p. 10895). *Ae aegytpi* is not originally from Brazil, but it has an "extraordinary capacity to adapt in the environment" (Câmara, *et al*, 2007, p. 193). This mosquito is characterized by a mainly *urban behavior*.

Only the female bites for blood, which she needs to mature her eggs; hence, it is only she who transmits the disease. Once the female mosquito is contaminated with the dengue virus, she becomes a permanent vector and it is estimated that 30% to 40% of the offspring will already be born infected (Ministério da Saúde, n.d. a). She puts her eggs on top of stagnant water, found in places such as empty cans and bottles, tires, gutters, uncovered water storage tanks, plates of potted plants or any other place that can store still water[30]. From the egg, a larva comes out and, during five to seven days, the larva passes through four different phases until it becomes an adult mosquito. In average, the mosquito lives around 30 days. The most favorable temperature for the development of the mosquito is between 25 a 30ºC; above 42ºC and under 5ºC it cannot survive (*ibid*).

After a contaminated mosquito bites a person, the symptoms will manifest themselves from the third to the fifteenth day. The symptoms last five to six days (Ministério da Saúde, n.b. c). The symptoms of dengue fever include severe headaches, fever, joint and muscle pain, and a characteristic rash. Dengue hemorrhagic fever (DHF) is a potentially deadly complication recognized by symptoms similar to dengue plus any one of the following: severe and continuous abdominal pain; bleeding from the nose, mouth and gums or skin bruising; frequent vomiting with or without blood; black stools, like coal tar; excessive thirst (dry

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[29] Nonetheless, pupae and larvae of the other vector *Aedes albopictus* were already found in the Roraima state, north of Brazil (Aguiar, et al., 2008)

[30] During her lifetime, the female *Aedes aegytpi* can lay down eggs an innumerable amount of times, and each time she lays between 150 to 200 eggs.

mouth); pale, cold skin; and restlessness, or sleepiness (Dengue Virus Net, n.d.). In Brazil, cases of dengue hemorrhagic stage have been reported in all states of the Union (Mendonça, Souza, & Dutra, 2009, p. 260). Patients with DHF can develop a hypovolemic shock, due to plasma leakage. This complication is the dengue shock syndrome (DSS) and it is characterized as dengue hemorrhagic fever in addition to: weak rapid pulse; narrow pulse pressure (less than 20 mm Hg); cold, clammy skin; and restlessness (Dengue Virus Net, n.d.)[31].

DF and DHF are often, though not exclusively, associated with poor environmental sanitation, inferior housing and inadequate water supplies. The diagnosis and management of DHF, as well as the control of outbreaks, may be a problem that can be addressed by primary health care workers (World Health Organization, 1997, p. 67).

Dengue is caused by a RNA flavivirus (Cummins & Ho, 2008) and there are four different but closely related serotypes of it: DEN-1, 2, 3 and 4. If a person recovers from infection from one of the serotype, it has lifelong immunity against that type but it only has partial and transient protection against the other three. Furthermore, "there is good evidence that sequential infection increases the risk of developing DHF" (World Health Organization, 2009). In Brazil all four serotypes are present, what contributes to the incidence of this disease. In 1981, DEN-1 and DEN-4 were isolated during an epidemic of dengue in Boa Vista, Roraima. After an epidemiological silence, in 1986 to 1987 the DEN-1 serotype invaded the Southeast (Rio de Janeiro, Minas Gerais) and Northeast (Alagoas, Ceará, Pernambuco, Bahia), spreading throughout the country ever since. In 1990-1991 the DEN-2

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[31] In their article *Dengue: uma nova abordagem* (Dengue: a new approach), Serufo *et. al* argue that the classical categories of dengue fever, dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) are outdated and hamper the decision-making process during the treatment of patients with severe forms of the disease because they failed to incorporate new concepts and therapeutic advances. They propose a new classification that incorporates concepts of sepsis, systemic inflammatory response syndrome and respiratory distress syndrome in adults (Serufo, et al. 2000).

was introduced in the country, and in 2001-2002 the DEN-3 (Câmara *et al*, 2007, p. 192). According to the Health Surveillance Secretariat (*Secretaria de Vigilância em Saúde*), with the entrance of DEN-3 in Brazil in 2002, there was increased mortality and hospitalization due to dengue in the subsequent years (Mendonça, Souza, & Dutra, 2009, p. 265). The only available treatment for dengue is what it is called "support treatment", i.e. "relief of symptoms, replacement of lost fluids and maintenance of the blood activity" (Ministério da Saúde, n.b. c).

Dengue is characterized by seasonality, with more cases happening during the warmer months. The *Ae. Aegypti* reproductive cycle is sensitive to variations in temperatures. In Brazil, on the second half of the year, when the temperature drops, the incidence of cases decreases significantly. Nonetheless, it does not contribute on stopping transmission.

Dengue has seen an increase in numbers and recurrent outbreaks around the world, and especially in Brazil. Several reasons have been pinpointed to explain this growth. Due to *Ae. Aegypti*'s sensitivity towards temperatures, one of the probable causes pointed out is the climate change. Warmer temperatures accelerate the mosquito cycle. With a temperature of 27ºC, the incubation period is ten days, however at 37ºC this period is reduced to seven days (Mendonça, Souza, & Dutra, 2009, p. 259)[32].

Another important cause pointed is the intense urbanization process, which usually happens on a disorderly manner and without the required health infra structured, combined with a rapidly growing population (Mendonça, Souza, & Dutra, 2009, pp. 258, 267; Mondini & Neto, 2007, p. 924). The urban environment stimulates the dispersion and density expansion of the *Ae. aegypti* population (Mendonça, Souza, & Dutra, 2009, pp. 264-265). This could

[32] An example that illustrates the influence of weather and climate changes in the proliferation from vectors of diseases such as dengue and also malaria was the *El Niño* phenomenon. During the years in which it happened there were an increase number of dengue and malaria epidemics, most probably trigged by the warmer temperatures (Mendonça, Souza and Dutra 2009, 259).

also be seen as an explanation for the higher number of cases in the Brazilian Northeast and Southeast regions as compared with the rest of the country. On these two regions are located

> the main attractive centers or cities that foster the spread of the virus and of the vector in the country. These cities attract workers, tourists and visitors that expose themselves to the infection there and carry the virus with them to their places of origin when they return. Also, numerous traffic routes that radiate from these centers contribute to the rapid spread of the virus and of the vector (Câmara *et al*, 2007, p. 195).

This supports the argument that maintenance of dengue virus does not depend solely of a large *Aedes aegytpi* population. An important element is a human population that ensures continuation of the virus existence on it. Câmara *et. al* (2007) in their study of dengue in Brazil argue

> the number of cases was associated with population size, and not with vector indices. In fact, *most (56%) municipalities that had vector index below the value recommended for epidemic risk, showed an outbreak*. It was not possible to relate this as non-native dengue cases, that is, infections acquired in city centers and then brought to the cities where residents are infected and less exposed to the vector. Nevertheless, this fact supports results described by other authors who *deny significant correlation between the Ae. aegypti density and epidemics dengue, being enough only the vector presence in the community*. Morrison et al do not consider important the density magnitude of vector in epidemics, needing only from 10 to 20 of female *Ae aegypti* per home, and that one or two of them are vectors (p. 195) [emphasis added].

Furthermore, another reason argued to be the cause for the increase in cases is ineffectiveness and negligence when it comes to public health policies and sanitation services. Mendonça, Souza and Dutra (2009) point the latter as the main motive for why the disease keeps coming back in Brazil. However, even though it is “associated with weaknesses in the health services (…), the fragility of individual actions towards protection of public health is also present” (p. 264).

During the 50s and 60s, after years of intense work to combat yellow fever – also transmitted by the *Aedes aegytpi* –, the mosquito was effectively eradicated from Brazil (Wilke *et al*, 2009, p. 65). “After the success obtained in this campaign, there was an apparent a lack of concern about controlling the mosquito, especially at a time favorable to its spread due to intense and disorganized urbanization in Brazil" (Mendonça, Souza, & Dutra, 2009, pp. 259-260). The mosquito's re-emergence and growth of dengue cases have had a disturbing and challenging progression in the last decades.

2.2 – "Fighting Dengue"

Since there is no vaccine[33] to prevent dengue fever, *vector control* has been the main approach used in public policies around the world. Nonetheless, as I have mentioned before, there are some controversies about what is the influence of the mosquito population size in the number of dengue fever cases.

Roriz-Cruz *et al*. (2010) compared two neighboring cities, Rio de Janeiro and Niteroí. Both cities have similar variables which would contribute to an elevated *Ae aegypti* infestation rate –usually associated with incidence of dengue: "(i) vapour pressure (a combined variable of humidity and temperature), (ii) population density, and (iii) environmental availability of disposable recipients that accumulate (rain) water" (*ibid*). Nonetheless,

> though sharing the same climate (vapour pressure = 68) and having similar population density (approximately 4000 people/km2) and sanitation rates, Rio had twice the dengue incidence (2036 cases per 100 000 inhabitants) of Niterói (1038 cases per 100 000 inhabitants) in 2008 (*ibid*).

The reason for that, according to the authors, is the difference between the cities' primary health care. Looking again at the two cities notice that

> in Niterói, the past 20 years have seen an increase in primary health care coverage from less than 1 to 77.4%. This was paralleled by a significant reduction, not only in the *Aedes aegypti* domiciliary infestation rate (from approximately 10% in 1986 to 1.7% in 2006), but also in the incidence of dengue cases during these years (from 1383 cases per 100 000 inhabitants in 1986 to 189 cases per 100 000 inhabitants in 2006). Conversely, only 7.2%

[33] In Brazil there are currently three research groups working in the development of a dengue vaccine. The one in the forefront is financed by Sanofi-Pasteur, a division from the pharmaceutical group Sanofi-Aventis, and predicts that by 2015 it will have developed a vaccine (Martins 2010).

> of Rio's population had primary-care coverage in 2008 (the lowest among Brazilian state capitals), and two aforementioned dengue indicators have not changed significantly in the last 20 years (*Aedes* infestation rate: from around 10% in 1986 to 7.2% in 2006; incidence: from 205 cases per 100 000 inhabitants in 1986 to 232 cases per 100 000 inhabitants in 2006) (*ibid*).

The authors challenge the argument that vapor pressure is the best natural predictor for dengue potential[34]. For Roriz-Cruz *et al*. (2010) there has been an ecollogically biased approach: the places with high vapor pressure are mainly located in the so-called developing countries and most of these do not present a fully implemented and comprehensive primary-care system. For them, the latter should be the focus of public policies.

Notwithstanding, in Brazil, public policies predominantly emphasizes vector control. Several alternatives have been attempted in the country[35]. On the national campaign against the disease "Fight Dengue" (*Combata a Dengue),* the major stress is on popular mobilization. The subtitle of the campaign is "Brazil is counting on you" and the website describes daily actions Brazilians should do to "prevent" dengue. The Communitarian Health Agent (*Agente Comunitário de Saúde* / ACS)[36] and the Endemic Control Agent (*Agente de Controle de Endemias* / ACE) visit houses and other buildings to guarantee that there are no recipients where there could be still water for the mosquito to lay its eggs. At the same time, these agents try to involve the population on "fighting the mosquito" (Ministério da Saúde, 2009)[37]. They also put larvicides in the places where still water cannot be eliminated, such as drains and water tanks (Ministério da Saúde, n.d. a).

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[34] See Hales, *et al*. 2002.

[35] Other alternatives include planting Neem trees (*Azadirachta indica*), which has natural substances in its sap that inhibits the feeding and reduces growth and reproduction of vector mosquitos. The municipality of Teresina, Piauí state, created a public vivarium, and in one year more than twenty thousand seedlings have been distributed (Jornal Hoje, 2011). In Apodi, Rio Grande do Norte state, an experiment using fishes to control de mosquito population is also under way (Jornal Nacional, 2011).

[36] There are around seventy thousand ACS in Brazil (BBC, 2011).

[37] The ACS and the ACE agents are allowed to enter private and public buildings regardless of the permission of the owner or occupant, through court order (Portal Brasil 2011).

Another option used is fogging, i.e., apply chemical insecticides, mainly organophosphates and pyrethroids (Luna *et al*, 2004), with nebulization machines, known in Brazil as *fumacê*. This alternative is usually employed only during epidemic periods. First, because its use might have some effect on the health of people and other organisms, and additionally the indiscriminate use of this resource can create resistant[38] mosquitoes (Braga & Valle, 2007, pp. 285-287).

Recently another solution has been proposed and researched in Brazil: the use of *genetically modified Aedes aegypti*. Some researches focused on what is defined as *population replacement*, which "aims to introduce a resistance mechanism to prevent transmission" (Wilke *et al*, 2009, p. 67). In 2004, Travanty et al. presented a study that introduced "anti-DENV genes into DENV competent mosquito populations" (p. 607). The research dealt specifically with the serotype DEN-2. Another example was the development of "a transgenic A. aegypti family containing an IR DNA construct that triggers the endogenous RNAi pathway against DENV-2 in the mosquito midgut" (Franz, et al., 2006, p. 4201). In other words, through the natural antiviral RNA interference (RNAi) they aimed to reduce the vector competence. In this study, the targeted virus serotype was once more DEN-2[39]. These two proposals, although researched in Brazil, have not been tried out in open field.

Besides population replacement, another mechanism of genetic control is *population reduction*[40]. In 2009 an article written by *Universidade de São Paulo* (USP) researchers

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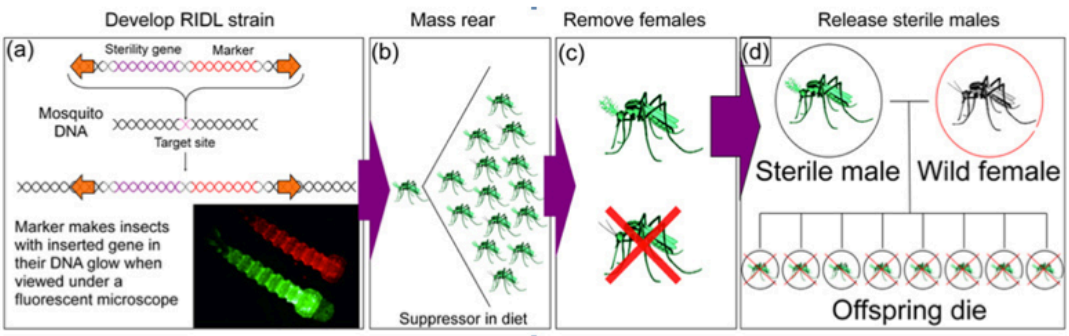
[38] Resistance is defined by WHO as the ability of an insect population to tolerate a dose of insecticide that, under normal conditions, would cause its death. The pre-adaptive resistance is the result of random mutations. Some individuals possess characteristics that allow their survival under normally lethal doses of insecticides. The insecticide itself does not produce a genetic change but its continued use can select resistant individuals (Braga e Valle 2007, 285-286).

[39] Another research presented transgenic *Ae. Aegypti* to fight malaria. Moreira et al. (2000) wrote about using carboxypeptidase gut-specific promoters that would be able to drive the expression of an antimalarial gene.

[40] For an overview on *population reduction* strategies for controlling transmission of mosquito-borne diseases see James 2005.

(Epidemiology and Parasitology departments) and from the British biotech company Oxitec – the Oxford Insect Technologies, a spin-out company from Oxford University[41] – presented the advantages of Sterile Insect Technique (SIT[42]) as a strategy to eradicate or suppress target populations. Insects can be sterilized through "irradiation, chemical, cytoplasmic incompatibility and translocations (or other chromosomal rearrangements)" (Wilke *et al*, 2009, p. 66). From the available SIT options, the authors suggest the RIDL® (Release of Insects Carrying a Dominant Lethal) technology to sterilize the insects. This technology genetically modifies the mosquitoes: they can only survive to adulthood in the presence of "a diet supplement" (Oxitec Ltd, n.d.). The Oxitec website does not mention clearly what is this supplement: it is tetracycline, "an antibiotic used to treat bacterial infections such as urinary tract infections, chlamydia and acne" (GeneWatch UK, 2010, p. 2). RIDL males are released into the indigenous mosquito population to compete for the wild females. Since the RIDL mutation is a dominant trace, all the progeny from a RIDL male with a wild female should be heterozygous for the lethal gene, and thus would die. In **Figure 2** we can see how the RIDL-SIT system would work:



[41] "Isis Innovation (Oxford University's technology transfer arm) was responsible for helping to set up the company and assisting to obtain venture capital investment. In August 2008, Oxford Spin-out Equity Management (OSEM) was set up to manage the University's shareholdings in its spin-out companies and seek ways of maximising the value of its equity stakes: Oxitec is now part of its portfolio" (GeneWatch UK 2010, 2). In the OSEM's website Oxitec is classified under "Other Health Care" and described as "effective and environment-friendly techniques to control insect pests that are damaging to public health" (OSEM n.d.)

[42] SIT is mainly used to control agricultural pests. For more information about this technique see Dyck, Hendrichs, & Robinson (2005).

Figure 2: Population reduction using a RIDL-SIT based system – "(a) the RIDL strain is developed using modern molecular biology techniques of transformation; inserting the RIDL gene system and a fluorescent marker into the insect of choice (in this case a mosquito). The insect picture in panel (a) shows green and red fluorescing Aedes aegypti larvae. Individuals expressing the fluorescent marker with a single insertion of the transgene are developed into a homozygous RIDL strain. The RIDL strain goes through rigorous testing to select a train with a suitable phenotype (i.e. late acting or female-specific lethality, bionomic and fitness studies). Once a suitable RIDL strain is developed it can be mass reared (b) in the presence of a suppressor (a dietary supplement that suppresses the RIDL system). (c) The females are removed, either mechanically or using a female-lethal system. The males can then be released to compete with the wild type male (d) for wild type females, offspring from a successful RIDL mating will die as there is no suppressor present. *Releases in large enough numbers over a sufficient time* will suppress, or even eliminate, the targeted population" [emphasis added] (Wilke, Nimmo, John, Kojin, Capurro, & Marrelli, 2009, p. 68).

One of the obstacles in genetic technology as a strategy for vector control is the competiveness / fitness of engineered insects when compared to the wild population. Some studies argue that transgene would result in fitness cost; the suggested reasons pinpointed are

> first, insertional mutagenesis resulting from the integration of the transgene into the host's genome could result in the partial or complete disruption of gene function. Second, the expression of the transgene may be detrimental to the organism. Finally, the process of creating transgenic insects involves at least two generations of brother / sister matings and results in significant inbreeding depression (Irvin *et al*, 2004, p. 896).

Wilke et al. (2009) advocate that this fitness cost would be true for the transgene insects adopting a *population replacement* mechanism (p. 67). However, when dealing with SIT-RIDL mosquitoes, these authors affirm that "modeling indicates that even a moderate fitness cost should not dramatically affect the critical release ratio required by RIDL particularly in comparison to the effect in competiveness of traditional methods of sterilization" (p. 69). It is also argued that RIDL technology is more "cost-effectiveness" than other SIT techniques, such as irradiation[43] (Oxitec Ltd, n.d.; Wilke *et al*, 2009, pp. 66, 69).

Oxitec Ltd[44] has developed the *product* (native category) *Aedes aegypti* OX513A, a bisex RIDL strain[45]. According to the company, only[46] males of this mosquito are released into the

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[43] "Irradiation of pupae appears to damage the insects; irradiation as adults is less damaging but operationally far more difficult. Some trials used sterilizing chemicals such as thiotepa, which proved effective for sterilization but led to trace contamination with this mutagenic chemical" (Phuc, et al. 2007).

[44] The Oxitec technology has won the Technology Pioneers 2008 award at the World Economic Forum (Cummins e Ho 2008). This award is given to "world's leading technology experts, including venture capitalists, technology companies, academics and media". They "have been identified as developing and

wild; there is a significant difference size between the two genders, which would allow them to be separated mechanically (Oxitec Ltd, n.d.). There is an important difference between the development of the progeny of mosquitoes sterilized by radiation or chemicals and the RIDL ones. The former typically results in progeny that dies during the embryonic development (Phuc, et al., 2007). The offspring from genetically modified mosquitos (GMM) and wild females – or "doomed heterozygotes" (*ibid*) – are characterized by a late lethality, which allows them to survive through larvae phase. Since these doomed heterozygotes compete for resources (e.g., for nutrients, space) with other larvae, this would contribute to the population reduction, when compared to the conventional SIT approach (GeneWatch UK, 2010, p. 3)[47]. According to model calculations, this larvae competition would result a 45% reduction on the amount of mosquitos required for eradication, when compared with classical SIT ones (Atkinson *et al*, 2007, p. 9544).

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applying highly transformational and innovative technologies in the areas of energy, biotechnology and health, and information technology. To be selected as a Technology Pioneer, a company must be involved in the development of life-changing technology innovation and have the potential for long-term impact on business and society. In addition, it must demonstrate visionary leadership, show all the signs of being a long-standing market leader – and its technology must be proven" (Oxitec Ltd n.d.).

[45] Oxitec has two other insect-products developed to fight dengue fever. One is the ***Aedes aegypti* OX3604C**, a flightless female RIDL strain: "when mosquitoes are reared without the antidote, tetracycline, adult females cannot fly or mate. Flightless females in the wild cannot seek hosts or mates, take a blood meal or spread disease. They are likely to be rapidly eaten by predators, so this trait is equivalent functionally to a lethal condition" (Oxitec Ltd n.d.). The other is the ***Aedes albopictus* (Asian tiger mosquito) OX3688**: a female-flightless RIDL strain as well. The process and characteristics are the same of OX3604C, but on the other species of *Aedes,* which can also transmit dengue fever – it has never been acknowledged a transmission through *Aedes albopictus* in Brazil. None of the products has been in "open field trials": OX3604C has had "contained trials" and OX3688 status is "product optimization" (Oxitec Ltd n.d.). For more information on the female flightless Aedes, see Mustafa, Bansal e Rastog 2011; Fu, et al. 2010. It should be noted that the latter is written mainly by Oxitec researchers but it states that "the authors declare no conflict of interest". Afterwards a correction was published: "The authors note that their conflict of interest statement was omitted during publication. The authors declare that those authors affiliated with Oxitec Limited (as noted in the author list) are or were employees or collaborative students of this company, which therefore provided salary and other support for the research program. Also, such employees may have shares or share options in Oxitec Limited. Both Oxitec Limited and Oxford University have one or more patents or patent applications related to the subject of this paper" (PNAS 2010 ?).

[46] We will see in Chapter 5 that this point is controversial: the separation between males and females is not precise and there is an error margin between 0,1% to 1%.

[47] As we will later discuss in Chapter 5, this is (one of) the reason the Oxitec's description of "sterile mosquito" is disputed: "they do reproduce but most of their progeny do not reach adulthood, *usually* dying at the late larvae/early pupae stage" [emphasis added] (GeneWatch UK, 2010, p. 3).

Opponents mention that, thus, it is a misleading action from Oxitec and others pro-GMM to define the OX513A as *sterile*: “they do reproduce but most of their progeny do not reach adulthood, usually dying at the late larvae/early pupae stage.” (GeneWatch UK, 2010, p. 3). At this point, it might be interesting here to bring forward the contributions made by scholars from discourse analysis. The *choice* of words does have an important role. Language is not a neutral medium for communicating information, but a domain in which our knowledge of the world is actively shaped (Tonkiss, 2000).

In the company’s website it is announced that the

> OX513A has regulatory approvals for import and contained testing in Brazil, Cayman Islands, France, India, Malaysia, Singapore, Thailand, USA and Vietnam. Open field trials have taken place in both Grand Cayman and Malaysia, and are currently also underway in Brazil” (Oxitec Ltd, n.d.).

It is the release of these genetically modified *Ae aegypti* that we will have look upon in following pages. The original idea was to focus on the Brazilian case, but, as noted, lack of information led me to include data gathered from the other two releases – Cayman Islands and Malaysia – to enrich the discussion.

2.3 – Releases of Genetically Modified Mosquitos (GMMs)

The first GMMs field trial in the world happened in the Cayman Islands[48], a British Overseas Territory[49]. In late 2009 there was a small trial of Oxitec’s RIDL strain OX513A; then from May to October 2010 a larger release was made at Gran Cayman. During these months three

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[48] Some argued that they opted for doing the trials at the Cayman Islands due to its biosafety considerations being not well developed (Nature 2011). Futhermore, there is a gap in the legislation: Cayman Islands is a non-party of the Cartagena Biosafety Protocal because UK’s ratification is not extended to its overseas territories (for more information on this legal controversy see the memorandum made by Consumers’ Association of Penang and Sahabat Alam Malaysia (2010).

[49] The use of an “Overseas Territory as a private lab” resulted in accusations of a colonialist attitude from Oxitec and collaborators (GeneWatch UK 2010 ?).

million mosquitoes were released on a 16-hectare site, in batches three times a week. (GeneWatch UK, 2010, pp. 8-9). The British biotechnology company worked in collaboration with the Mosquito Research and Control Unit (MRCU) from the Cayman Islands.

On October 4, 2010 – hence, after the OX513A had been released – MRCU posted a promotional video. The video explained that *sterile* mosquitoes were being set free in the islands, but it did not mention that those were genetically modified ones (Cayman Islands Government, 2010)[50]. Researchers from the UK based company disclosed the results of this first field trial with the genetically modified mosquitoes in November 4, 2010, at the American Society of Tropical Medicine and Hygiene (ASTMH) annual meeting in the United States; hence the international scientific community was informed only *after* the releases had already happened (Subbaraman, 2011, p. 9; Nightingale, 2010). An article published in Science mentioned that the way Oxitec had conducted its trails had resulted in "strained ties" with collaborators, such as Bill and Melinda Gates foundation[51]. It also mentioned that Anthony James from University of California, Irvine – who also researches GMMs – would have said that he would "never release GM mosquitoes the way Oxitec has now done in Grand Cayman[52]" (Enserink, 2010).

During an interview, Luke Alphey, chief scientific officer of Oxitec and one of the company founders, declared he "completely rejects" that there was anything secretive about the releases. He declared that "we did lots of engagement work in Cayman, but no special effort either to spread the word internationally or not to [do so]" (Nightingale, 2010). According to

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[50] The vídeo can be seen on youtube: http://www.youtube.com/watch?v=tv6JsC2MQYI.

[51] In an interview to Nature Biotechnology, Alphey expressed that "he was 'surprised that Science chose to present the story the way they did.' If there is a controversy around the way Oxitec prepared for the trials, he says, it has not officially been directed at his company" (Subbaraman 2011, 9).

[52] James is running trials in Mexico, in collaboration with the Bill and Melinda Gates Foundation (Subbaraman 2011).

the results presented at ASTMH, there was an 80% reduction in the mosquito population[53] (Subbaraman, 2011).

The second release was made in Malaysia in collaboration with the local Institute for Medical Research (IMR). In 2006 the country imported the OX513A strain (Chinnock, 2011 b). When the Malaysian government began the process to authorize the introduction of GMM into the environment, some local and international civil organizations and scientists expressed their disagreement[54]. A postponement of the trials was announced – some arguing that it was a response to protests made by groups against it (Chinnock, 2011 a), others claiming that it was because of rains (Shaik, 2011). Nonetheless, in January 26, 2011, the IMR issued a statement saying that during December 21, 2010 to January 5, 2011 the mosquitos had been released (Enserink, 2011). In an uninhabited region, near the town of Bentong, six thousands OX513A GMM had been freed in the forest area together with another six thousands non-GM for comparison (Connor, 2011). It seems that this "news came as a surprise both to opponents of the insects and to scientists who support them" (Enserink, 2011). An editorial published at Nature (2011) declared

> the move took many local people and international observers by surprise. They had thought that the trial, which aims to investigate how long the modified insects live and how far they can fly, had been postponed. The mix-up was down to the media confusing the trial with a second planned experiment, due to take place in a populated area later this year (p. 139).

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[53] Oxitec claims that this experiment was a 'success' based on preliminary results made only by researchers linked to the company – there was no independent parallel investigation. Besides a reduction of 80% in the population, Oxitec did not made it clear what were the company's other criteria to define it as a success (Consumers' Association of Penang; Sahabat Alam Malaysia, 2010). Furthermore, these results were presented only a few days after the experiment ended. This contradicts a paper by some Oxitec researchers: "SIT programs *do not have immediate effects on vector numbers*. The sterile males impact the size of the wild population in the next generation, not the current one. Significant population reduction should be seen after a small number of generations, but this is likely to be weeks or months rather than hours or days" [emphasis added] (Alphey, et al., 2010, p.299).

[54] See Consumers' Association of Penang; Sahabat Alam Malaysia 2010, Steinbrecher 2010, International Civil Society Organizations 2010. The latter was signed by more than 50 organizations around the world.

The editorial tackled the topic of public consultation in trials like the one that had just happened in the Asian country and it expressed that

> there is no suggestion that any of the releases was unsafe, or contravened any law. In line with Malaysia's biosafety rules and the Cayman Islands' draft rules, permits were issued after the relevant national authorities performed risk assessments. But scientists and local people alike have taken issue with the manner in which the public engagement was handled (*ibid*).

In the Brazilian case, it is local researchers who are carrying out the trials, under the coordination of Professor Margareth Capurro[55], a professor at USP`s Parasitology Department[56]. In an interview, she explained that she met Luke Alphey, from Oxitec, in a conference, and he suggested she should try out the *Aedes aegypti* OX513A in Brazil (Sociedade Brasileira de Parasitologia, 2011). As noted in Chapter 1, all activities with genetically modified organisms have to be approved by CTNBio. In the Commission's first statement – it is defined as a prior statement (*extrato prévio*), given before the decision to authorize or not is made – about genetically modified *Aedes aegypti*, issued on January 30, 2009, these GMMs were classified as "biological risk I" (CTNBio, 2009 a). Biological risk I is the lowest class possible, meaning that it represents "low risk for the individual or the community" (Ministério da Saúde, 2010).

On August 27, 2009, CTNBio granted an "extension of the Biosafety Quality Certificate (CQB - *Certificado de Qualidade em Biossegurança*) for activities with genetically modified animals under the risk II class" to the laboratory under the responsibility of Prof. Capurro (CTNBio, 2009 b). Risk II is considered to be of "moderate individual risk and limited risk

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[55] Several times in the Brazilian media the information was that researchers from USP had developed the GMMs. That is the information found, for example, at the governmental website of the campaign against dengue from the Rio de Janeiro state. "Under the coordination of Professor Margareth Capurro, they [researches from USP] have *created* a genetically modified *Aedes aegypti*" [emphasis added] (Governo do Rio de Janeiro 2011).

[56] Margareth Capurro coordinates another project entitled "Promoting mortality in *Aedes aegypti* infected by the dengue virus" (*Promovendo mortalidade em* Aedes aegypti *infectado pelo vírus da dengue*) which received 347.263,34 reais of pubic investment from the Foundation for Research Support of São Paulo (*Fundação de Amparo à Pesquisa do Estado de São Paulo*). This research aims to develop a transgenic mosquito that dies once contamined with the dengue virus (Silveira E. d., 2011).

for the community" (Ministério da Saúde, 2010)[57]. The document included an explanation of why there was a risk change type: "PS: The mosquitoes species genetically manipulated in this laboratory are included in the risk II class because they are vectors for viral diseases – Aedes aeggypti" (CTNBio, 2009 b). They were classified as risk II on all following statements and authorizations.

In September 21, 2009, CTNBio authorized the request[58] to import three batches of five thousands embryos from Oxitec in the UK (CTNBio, 2009 c). The commission's document declares "these insects will serve as biological models to control vectors from diseases that affect humans (*ibid*). In an interview, Margareth Capurro tells "a week after we received from Oxitec, *no charge*, an envelope with five thousand eggs". (Sociedade Brasileira de Parasitologia, 2011) [emphasis added].

She started raising transgenic *Aedes aegypti* in her lab at USP. Nonetheless, in order to be able to introduce them into the wild, the GMMs need to be bread in larger scale. It was decided that the mosquitoes could be developed at the Social Organization[59] Moscamed Brasil founded by Aldo Malavasi – a former professor from USP. It already worked with mosquitoes, developing SIT fruit flies (*Ceratitis capitata*)[60] through irradiation in large scale (Moscamed Notícias, 2011 b). To enable this, a "technical and administrative agreement" was signed by USP and Moscamed. It established the 'field laboratory of transgenic insects',

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[57] The classification is: I) low risk for the individual or the community; II) moderate individual risk and limited risk for the community; III) high individual risk and moderate risk for community; IV) high risk for the individual and the community (Ministério da Saúde 2010).

[58] The request was made under the name of the Biomedic Sciences Institute (*Instituto de Ciências Biomédicas*) from USP.

[59] As a social organization it is linked to the Ministry of Agriculture, Livestock and Supply (MAPA). To be a social organization means that the company can sell its products and services and make profit, but all has to be reinvested back into the business. Moscamed received a contribution of twelve millions reais from three different Ministries (MAPA, Science and Technology, and National Integration). Furthermore, from the Bahia Government it received a donation of 60 thousand meters of land and of five thousand of constructed area, priced at seven millions reais (Ereno 2007).

[60] In 2007, it was estimated that the fruit fly caused a damage of 120 millions to Brazilians fruit farmers (Ereno 2007).

an extension of UPS`s Department of Parasitology, which was installed in Moscamed (Moscamed Notícias, 2011 a). The biofactory does not charge for carrying out the task. According to Malavasi, this decision was made because "with these trials we gain visibility, technical training, at the same time that we may gain an alternative to control these bugs" (Sociedade Brasileira de Parasitologia, 2011).

In December 17, 2010 – after one prior statement issued in July 22 of that same year – the CTNBio authorized the request[61] for the "planned release of genetically modified insects in the environment" (CTNBio, 2010 b). The document states that

> the insects will be released in five different locations, under the responsibility of Prof. Dra. Margareth de Lara Capurro-Guimarães. The insects that will be released are from the specie Aedes aegypti, lineage OX513A expressing a fluorescent protein from the GFP superfamily, trigger factor for the tetracycline-repressible (tTA) transcription. The transformed mosquitoes will have two new biological activities, which are: fluorescence and repressible lethality. The insects are originally from the company Oxitec- Oxford Insect Tecnologies [sic] (Oxford, England) and maintained and multiplied by the Social Organization Biofactory Moscamed Brasil holder of the CQB 312/10[62]. (…) The proponent requests that *the information given by her is to be regarded as confidential by CTNBio* (*ibid*) [emphasis added].

In CTNBio's document there is no mention on where these "five different locations" will be. The chosen place was Juazeiro, in the Bahia (BA) state, where Moscamed`s biofactory is situated. The chosen locations are "isolated due to crops, roads or unpopulated areas, and, additionally, they have a high incidence of *Aedes aegypti*" (Sociedade Brasileira de Parasitologia, 2011). Additionally, Capurro mentions that one advantage of carrying out the trials in Juazeiro is that "due to Moscamed's operations in the region, the population is *already used to insects' release* into the environment. *For that reason they will not fear the ones we plan to free*" (*ibid*) [emphasis added].

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[61] The request was once again made under the name of the Biomedic Sciences Institute from USP.

[62] The CQB for risk II was given to Moscamed in August 25, 2010 (CTNBio 2010).

The release of OX513A strain in the country is called Aedes Transgenic Program (PAT / *Programa de Aedes Transgênico*) or Genetic Control of the Aedes Aegypti Mosquito Program (*Programa de Controle Genético do Mosquito Aedes Aegypti*). In Moscamed's website it is stated that "the PAT will be carried out in the neighborhood of Itaberaba, in Juazeiro, as well as in the districts of Carnaíba, Mandacaru and Maniçoba" (Moscamed Notícias, 2011 b).

In February 2011, the first phase was carried out: some releases in smaller numbers to evaluate the GMM's behavior (Cristino, 2011). In April 30, the second phase started, with larger releases[63]. In July 1st, the *Diário do Congresso*, the newspaper from the National Congress informed that

> in the dirt streets of the neighborhood Itaberaba, in Juazeiro (BA), a cart with two researchers stops every hundred meters. One of them goes down and uncovers a pot, to free around five hundred mosquitoes *Aedes aegypti,* the dengue vector. The scene repeats itself for three weeks now and, until July, *33,000 males per week are expected to be release*. After, this number will go up to *50,000 to 100,000 mosquitoes per week*. (…) The experiment will occur for eighteen months in five neighborhoods of Juazeiro [emphasis added] (Diário do Congresso , 2011).

In an interview Margareth Capurro explains that for each wild male, *five to ten GMMs* have to be introduced into the environment. She also explains that there should not be a significant decrease of the wild population with the first trials, but only after it happens during two summers (Sociedade Brasileira de Parasitologia, 2011).

The GMM solution fits the approach proposed by Alvin M. Weinberg, on his now famous article written in the 60s, *Can Technology Replace Social Engineering?*. He argues that social problems are much more complex and harder to pinpoint than technological ones. Furthermore, they are more complicated to solve because social engineers must cause social

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[63] In the Bahia`s Government website there is very little information about the release. There are only some pictures of the first release, with the participation of local authorities. Later there is a comment from the Governor Jaques Wagner (PT) saying "Once the work is finished, Bahia will be the first Brazilian state to use the transgenic mosquito, considered to be a much more efficient weapon on the fight against the disease"

change by inducing people to behave differently – through legal, moral, organizational, and educational devices – and changing human behavior is a difficult task[64]. According to him, "by contrast, technological engineering is simple" (Weinberg, 2006, p. 28). Thus, due to the simplicity of technological engineering and the complexity of the social one, he proposes to circumvent social problems by reducing them to technological ones. He coined the term 'technological fix' – now part of the science and technology studies lexicon – to technologies that "eliminate the original social problem without requiring a change in individual's social attitude, or would so alter the problem as to make its resolution more feasible" (p. 28-29). Although he recognizes that technological solutions can be "incomplete and metastable" (p.33) he still advocates that technological fixes are more "practical, and, in the short term, relatively effective" (p.32). Since *vector control* is the main (if not only) approach from Brazilian public policies to control dengue and inducing people to change their behavior is perceived as a complex task, the OX513A can present itself as a *obligatory passage point* on the 'fight' against dengue. It would allow to suppress the mosquito population through a technology, and, thus, requiring little effort from the human population.

[64] Weinberg discusses in terms of lack of rationality in human behavior. For him, "People don't behave rationally; it is a long, hard business to persuade individuals to forgo immediate personal gain or pleasure (as seen by the individual) in favor of longer term social gain" (Weinberg, 2006, p.28).

Chapter 3 - Same Same or Different? -

3.1 – Principle of Substantial Equivalence and the Precautionary Principle

When dealing with the decision-making process around new technologies (e.g. GMOs or GMMs) there are two distinct approaches: the *principle of substantial equivalence* and the *precautionary principle*.

The *principle of substantial equivalence* was developed by the Organization for Economic Cooperation and Development (OECD) in 1993. While discussing safety of genetically manipulated food, it was proposed the use of existing organisms as a basis for comparison "on components that has been modified or is new" (OECD, 1993). In the organization's website it is defined as a concept "which stresses than an assessment of a novel food, in particular one that is genetically modified, should demonstrate that the food is as safe as its traditional counterpart" (OECD, 2001). Since the introduction of this principle by OECD, other institutions such as Food and Agricultural Organization and World Health Organization have endorsed the use of this concept in regulatory decision-making (Schenkelaars, 2002). Usually used as an argument to speed the regulatory process, it defines that if a GM can be characterized as a substantially equivalent as its "conventional analogue" it can be assumed it poses no new risks (Millstone, Brunner, & Mayer, 1999, p. 525).

However, according to Millstone, Brunner and Mayer (1999) the concept is marked by vagueness:

> the concept of substantial equivalence has never been properly defined; the degree of difference between a natural food and its GM alternative before its 'substance' ceases to be acceptably 'equivalent' is not defined anywhere, nor has an exact definition been agreed by legislators (p. 525).

In the case of GMOs, Neuza Brunoro Costa and Aluízio Borém (*apud* D. L. Vieira 2007) pinpoint four characteristics that must be meet when doing a study to prove substantial equivalence. The first one is *phenotypic and agronomic equivalence,* i.e., show that there are no "unforeseen biological effects" due to the genetic modification. The second is *composition equivalence* means that the organism is evaluated to see whether it displays the same composition of macro and micronutrients, excluding the "intentional changes made in one or more component". Thirdly, the *safety equivalence* can be obtained through an "assessment of hazards associated with the inserted trait and/or its intermediate metabolites and/or phenotypic and composition characteristics". And finally, the *nutritional equivalenc*e: usually a series of tests are done, around 42 to 120 days, in order to identify effects on nutritional parameters and even to evaluate economic advantages or disadvantages (p. 101). Nonetheless, as Millstone, Brunner and Mayer (1999) point out, it is not very clear what is the limit between considering something substantially equivalent or not anymore[65] (p.525).

Hence, the basic premise is that there is a substantial equivalence between the genetically modified organism and its "natural antecedent". If the first does not incur in risks, the latter will not either, and can therefore be released. This principle is often used as an argument against labeling – which, in an equivalence context, would only serve as a "prejudice decoy" for the transgenic product (Cesarino, 2006, pp. 80-81).

Conversely, another approach – one marked by precaution – emerged in German environmental policy. This approach is usually championed by environmentalists and consumer protection groups, and opposed by industries (Stirling, 2007, p. 309). The

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[65] For these authors the vagueness of subtantial equivalence would be "useful to industry but unacceptable to the consumer". In the context of GM food, they highlight that "from the point of view of the biotechnology industry, this approach [one which does not adopt substantial equivalence] would have had two main drawbacks. First, companies did not want to have to conduct toxicological experiments, which would delay access to the marketplace by at least five years, and would add approximately US$25 million per product to the cost of research and development. Second, by definition, using ADIs ['acceptable daily intakes'] would have restricted the use of GM foods to a marginal role in the diet. An ADI is usually defined as one-hundredth of the highest dose shown to be harmless to laboratory animals. Thus, even if the animals show no adverse effects on a diet consisting exclusively of a test material, human intake would still be restricted to 1% of the human diet. The biotechnology companies want to market GM staples, such as grains, beans and potatoes, which individually might account for as much as 10% of the human diet, and collectively might provide more than half of a person's food intake" (Millstone, Brunner, & Mayer, 1999, p.525)

precautionary principle was first officially defined at the United Nations Conference on Environment and Development held in Rio de Janeiro 1992. In this meeting's declaration it is defined as:

> Principle 15: In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (UN Documents, 1992).

In the literature about precautionary principle it is framed in very diverse manners, and it is not my intention to cover here the entire debate on it. One of the strongest critiques towards the principle is its variety and unclear formulations that sometimes prevents to give clear definitions and guidelines for how it should be applied. Thus, "the problem with basing the precautionary principle on qualitative decisions [would be] that it is either normatively empty or an unreasonable qualitative decision rule (Peterson, 2007, p. 306). To argument against these accusations Andy Stirling (2007) defends that

> the precautionary principle is not—and cannot properly claim to be—a complete decision rule at all. Unlike many of the techniques with which it is compared, it is, as its name suggests, more a general principle than a specific methodology. In other words, it does not of itself purport to provide a detailed protocol for deriving a precise understanding of relative risks and uncertainties, much less justify particular detailed decisions. Instead, it provides a general normative guide to the effect that policy-making under uncertainty, ambiguity and ignorance should give the benefit of the doubt to the protection of human health and the environment, rather than to competing organizational or economic interests (p. 312).

Some scholars have attempted to give some outline on how to implement the precautionary principle. Ana Gouveia Freitas Martins (*apud* Hammerschmidt, 2002), for example, pinpoints seven fundamental ideas that should be considered: (1) when facing serious damages to the environment, even if there is lack of scientific evidence which proves causality, measures must be taken to stop the threat; (2) reverse the burden of proof, in other words, whoever wishes to pursue a given activity or release a new technology is the one who must prove that the associated risks are acceptable; (3) *in dubio pro environment or in dubio contra* *projectum*, i.e., if there is any doubt if the activity or technology can cause serious or irreversible damage, the risk of error must be weighted in favor of the environment; (4) the environment should be given a leeway in which the limits of environmental tolerance are not forced nor violated; (5) demand the development and introduction of the best available techniques – BAT; (6) guarantee the preservation of natural areas and reserves, and likewise the protection of species; (7) promote and develop scientific research on the effects and potential risks of a given activity or technology (pp. 113-117).

Thus, the precautionary principle requires active exercise of doubt, in which there must be a constant review of new and old knowledge and points of view, adopting an open and contingent approach. All hypothesis must be taken into consideration, even the most marginal or extreme – that is what Callon *et al.* (2009) define as dealing with worst-case scenarios – or even unpredictable and unimaginable ones (pp. 199-200).

Some accuse precautionary measures to be counter-productive, irrational, ignorant of scientific results, or of (unnecessary) higher costs (Renn, 2007, p. 303). Another critique aimed at the principle is that it leads to inaction "because it holds that when decision-makers lack sufficient knowledge about the effects of a potentially dangerous activity, one should not proceed" (Peterson, 2007, p. 305). Objectors argue that these measures would be contrary to the idea of technological and scientific progress. Skepticism and even questioning about certain technologies are sometimes labeled as an antitechnology sentiment (Stirling, 2008, p. 264); and anyone who underlines the (possible) negative effects of a new technology or business activity is pointed as a threat to economy and development (Beck, 2009, pp. 214-215). In other words, opponents to the principle claim that its implementation means inaction. In the so-called developing countries this latter argument has an even a stronger weight. In countries characterized by poverty, the progress discourse comes associated with quality improvement of its population. The Brazilian layer Paulo de Bessa Antunes (2005), for example, argues in juridical terms against the principle: it would violate the "constitutional principles of human dignity, of work value and free enterprise prevalence, in this way frustrating the Republic's fundamental goals which are: to guarantee national development (CF art 3o, II) and to eradicate poverty and marginalization (C.F, art 3o, III)".

As many defenders of the precautionary principle remind us, it does not necessarily imply issuing a ban (Asselt & Vos, 2006). It is "rather a step-by-step diffusion of risky activities or technologies until more knowledge and experience is available" (Renn, 2007, p. 303). Additionally, the main purpose of the principle would be to avoid the irreversible decisions (*ibid*, p. 304).

3.2 – GMM and the Two Principles

Thus, the substantial equivalence bases itself on a comparison between the genetically manipulated organism and its conventional analogue. Meanwhile the precautionary principle prescribes that the GMO should be comprehended in interaction with the environment where it will be introduced.

In the controversy around genetically modified mosquitos, we can discern these two distinct approaches. In the article *Mini-review: Genetic enhancements to the sterile insect technique to control mosquito populations* – written by researchers from USP and Oxitec – RIDL is presented as one other development in the sterile insect technique. They construct the article by first explaining how SIT has been around since 1930s and that throughout the years "SIT is a *proven*, cost-effective and environmentally safe strategy for eradication or suppression of target populations" (Wilke *et al*, 2009, p. 66) [emphasis added]. They historically outline the advances of SIT as a tactic to vector control and that "with the advent of modern biotechnology it has become possible to improve the applicability, efficacy, safety and efficiency of the SIT" (*ibid*). It is argued that the "conventional SIT has a long history of safe use" (Alphey, *et al*., 2010, p. 306), and since RIDL is a method part of sterile technique, it should also be perceived as safe use. They explain that

> RIDL strains have a short additional segment of DNA; this does not encode any toxin or toxic gene product, or, importantly, any component that would confer a selective advantage to any insect or microbe that might somehow take up all or part of this DNA. (…) For all of these methods, to a predator or a scavenger eating the mosquito, or a mammal being bitten by one, the *consequences would be exactly the same as if this were a normal wild mosquito* (*ibid*) [emphasis added].

Thus, OX513A strain is understood as just an extension of a traditional technique for reduction and/or suppression of mosquito population. Since it is *substantially equivalent,* it can fall under the legislation and risk assessment of the already long used SIT.

Nonetheless, an alternative way to frame it is to perceive the GMMs not as part of a continuum, but as something completely new. In an approach marked by precaution, it should not be evaluated in comparison to its "traditional counterpart", but in how it relates to the environment. Hence, the RIDL would be assessed and regulated as a new technique, depending on how it relates to the surrounding.

Another example to be looked upon is the risk classification conferred by CTNBio to the GMM. This time, however, the traditional equivalent was not the other SITs but the *Aedes aegypti* mosquito. OX513A strain was classified as risk II because *Ae aegypti* can be a vector for viral diseases; it was evaluated according to the characteristics of its conventional counterpart. According to the precautionary approach it would be assessed and classified based on its own characteristics.

Letícia Maria Costa da Nóbrega Cesarino (2006) examines how the substantial equivalence principle has been the basis for the GM liberation in Brazil, especially in the years preceding the 2005 Biosafety Law. When in 1998 CTNBio authorized the genetically manipulated soybeans it accepted Monsanto's studies which demonstrated the substantial equivalence from RR in relation to the non-modified soybean. The argument was that the risks around GM soybean were the same of the conventional analogue, and, thus, it could be authorized without EIA/RIMA (Cesarino, 2006, pp. 80-81). Furthermore, the commercial release of a transgenic is made unrestricted to the entire country (Campanha Brasil Ecológico Livre de Transgênicos, 2011, p. 2). Brazil is a vast land with many diverse biomes. Nonetheless, CTNBio does not require specific studies for the different ecosystems.

Besides not perceiving genetically modified organisms as a continuum from its traditional counterparts, those who promote the precautionary principle advocate for what is defined as *reverse burden of proof.* This means that it is those who are trying to introduce a new technology or activity are the ones who need to prove it is safe, rather than those claiming they are hazardous. The reverse burden of proof does not occur in the Brazilian context. For example, between 2008 and 2010 CTNBio approved the commercial use of twenty-six transgenic seed, based almost entirely on information from the company requiring the authorization (Campanha Brasil Ecológico Livre de Transgênicos, 2011).

Chapter 4 - Risk and Uncertainty -

4.1 – Risk and Uncertainty in the Literature

In this chapter I examine some of the most prominent literature around the topic of risk and uncertainty. It is not my intention to review the entire literature, but rather to bring forward some ideas and concepts that can be interesting to put a light over the GMM debate.

In 1986 the German sociologist Ulrich Beck wrote the book *Risikogesellschaft: Auf dem Weg in eine andere Moderne* (Risk Society: Towards a new modernity). He claims that modernity is moving towards a new phase characterized by reflexivity, going beyond its classical industrial design which aimed to control nature and free humanity from traditional ties. The focus now is not only to increase technoeconomic development, but our attention is also directed at our traditional modern institutions, which do not seem to be adapted and relevant for dealing with the new risks and side effects caused by this very development. We would hence be entering in what Beck defines as the risk society. According to Beck (2009), the new, modern risks are different from those related to work accidents or to industrial risks from the 19th century. They are no more restricted to a certain place or a specific group of people, and they are usually difficult to be contained (p. 13). Before risks could be perceived by senses but they have now become invisible threats hidden as physical and chemical formulas (p. 21).

Nevertheless, Bruno Latour (2003) reminds us that we should not interpret these ideas as if people nowadays are living a more dangerous and risky life nor that people nowadays are more ‘aware’ or ‘conscious’ (p. 36). What has changed is that now there is a “heightened awareness that mastery is impossible and that control over actions is now seen as a complete modernist fiction” (*ibid*).

Risks that are produced are themselves the consequences of previous *decisions* – actions or omissions – and they can hence be considered as politically reflexive (Hammerschmidt, 2002, p. 98; Beck, 2009). Nevertheless, only a small portion of this decision-making process happens under the rules of public inspection and justification. The German sociologist draws the attention to a trend where political becomes apolitical, and vice-versa. On one hand, there is an increasing scientifization of political decisions: when facing uncertainty, political agents usually tend to follow what scientific expertise recommends. Thus, science is asked and sometimes pressured to provide *ad-hoc* solutions and most of the times these solutions are not widely debated. On the other hand, science and technology are truly transforming our daily lives. Nonetheless, these transformations and the level of risk that society should face is somewhat defined inside industries and laboratories, which for the most part have autonomy in their options and investments, and in how they will apply new technologies (Beck, 2009, p. 187). As we will see in Chapter 5, for Beck (2009), this is partially possible because of the legitimizing power of the idea of technological and scientific progress (p. 214). The release of GMMs in Brazil – as well as GMOs – can be characterized under the *modern risks* described by Ulrich Beck. First, because they are products of technoscientific development, and their release was an *option*. Secondly, it is constantly associated to the notion of progress, which is presented again and again as a golden Eden that science and technology can help to reach quicker and better, legitimating the decision to release.

In Beck's analysis, the definition of modern risk opens a new political window, which can and must be used to (re)conquer and strength the democratic influence and power. Because they are surrounded by new type of uncertainty, modern risks provide the decision-makers with a renewed legitimacy to recover part of the political power that had become almost entirely devoted to scientific experts. Political actions can make a difference in the detection and perception of risk potential. Beck (2009) highlights that there is never one single option, but many; and the selection of one over the others must be collectively constructed. Denise Hammerschmidt (2002) summarizes well how this process should be:

> society has the undisputed right to know the dimension, the characteristics and the nature of the risks involved before any new enterprise. Once the risk is *known* through adequate and correct information, there must be the possibility for debate and finally promotion of a political decision among the many alternatives (p. 120) [emphasis added].

Nonetheless, if this line of thought defines risks by their causal interpretations, and therefore risks exist in terms of knowledge (scientific or non-scientific) (Beck, 2009, p. 23), others have been arguing that it is impossible to have full knowledge over all options, nor to know all the solutions that might come to existence (Callon, Lascoumes, & Barthe, 2009; Barthe, 2009). We must extend the awareness that mastery is impossible, and realize the unimaginable complexity of risks. Latour (2003) also highlights this point, stating that risk "does not mean that we run more dangers than before, but that now we are entangled" (p. 36). He compares risk to the notion of network – a way to trace the complex relations of contemporary world – where "literally anything has to be taken into consideration"[66] (p. 37).

Therefore, even when it would be possible, sharing information, analyzing alternatives and then producing a collective decision would not be enough to deal with current issues. Callon, Lascoumes and Barthe (2009) in the book *Acting in an Uncertain World: an essay on technical democracy* affirm that the notion of *risk* cannot comprehend the uncertain situations we must deal with. Risk is related to dangers that can be identified, can be known; even if they do not happen we are aware that they might happen. They propose to work with the idea of *uncertainty* in order to highlight that science – or any other form of knowledge – cannot predict and describe all conceivable options, let alone the alternatives that for now are still unconceivable.

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[66] Latour (2003), hence, opposes to economist's notion of *externality*, i.e., whatever does not need to be taken into account; in a network approach everything matters.

Yanick Barthe (2009) argues that the choice of operating with the notion of *risk* or *uncertainty* has political consequences.

> To switch from uncertainty to risk assumes two types of operations: on one part, to define and to stop the list of possible worlds, and on the other, to calculate their occurrence probability. When the question of risk is raised, we usually focus on the second operation, the probabilities' calculation, while the first operation type bears much heavier consequences: it is in fact a particularly strong framework [*cadrage*] since it leads to the closing the possible worlds list in favor of states of the world known and "pertinent" in terms of probability calculus. That happens in detriment of possible states still unknown, undefined because not yet imagined or unimaginable, as well as possible worlds imaginable but unruly [*rétifs*] to calculation (p. 123).

Brunet, Delvenne and Joris highlight that even though uncertainty has always been part of the construction process of scientific knowledge (Popper *apud* Brunet, Delvenne, & Joris, 2011), this uncertainty has been maintained inside the doors of the scientific community and signals of certainty have been sent to the 'outside' world. They argue, supported by the writings of François Ewald, that there has been an awakening of the "vulnerability while facing new risks characterized by multiple uncertainties" (*ibid*) and awareness that the systems based on insurances, probabilities and financial compensation are no longer sufficient nor adequate for dealing with modern risk. These changes also result in political transformations. Before it was thought that once the risk was identified and established, one could act based on that information – usually only scientific information. One could then select the measures to be adopted in order to deal with forecasted situations or at least probabilistic ones. There is now the increased awareness that action is needed if there is still uncertainty, and some specific tools like the precautionary principle emerge as policy tools that try to cope with the complexities and uncertainties (*ibid*).

Based on this literature discussion, we will analyze how the GMMs were approached differently. Those advocating for its usage defined it solely as a risk – the knowledge is possible of calculation and mastery. Meanwhile those criticizing it, approached simultaneasly as risk and uncertainty – part of the issues are presented as predictable problems and other as incalculable or unimaginable. There was also an attempt by the latter to translate what was defined as risks by those pro-GMM into uncertainty.

4.2 – A mosquito entangled in risks and uncertainties

Through the light of the literature about risk and uncertainty, in this subsection we will present the major controversial topics around genetically modified mosquitos. Two opposing – but related – networks can be outlined: those pro and those against GMM[67], concomitantly try to negotiate the identity of other actors[68] such as the female GMM, the (not so) doomed heterozygotes, tetracycline, etc. These actors are defined in competitive and many times contrastive ways.

The first controversial point is the separation of males from females. Aforementioned, Oxitec states that only *Aedes aegypti* OX513A males are released into the wild. They mobilize the difference on size between male and female, which would permit a mechanical separation. Nonetheless, this is not a completely accurate process. In an article where some of the authors are researchers from the British company it is declared that "early Aedes SIT trials showed that, even on a large scale, sex-separation based on pupal size can consistently give an essentially male-only population for release (< 1% female; as low as 0.1% female if larger males are also discarded)" (Phuc, et al., 2007). This fact is not mentioned in Oxitec's campaigns. Those who advocate against GMM exploit the dissidence of the *Aedes aegypti* OX513A female, which resists the attempt of scientists to separate it from the males, and thus

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[67] Since I tried to 'follow the actors', the ones described here tended to have stronger opinions or be explicitly related to the subject. A criticism that can be made – common in the Feminist literature – is that this approach does not account for those who are 'invisible' or not explicitly involved, but still affected by it (Oudshoorn & Pinch, 2008, p.546).

[68] In an ANT or sociology of translation vocabulary, the "attempts to impose and stabilize the identity of the other actors" is defined as interessment (Callon, 1986, pp. 203-204).

to enroll it: the release of genetically manipulated females could eventually transmit dengue fever (Consumers' Association of Penang; Sahabat Alam Malaysia, 2010, p. 19). Furthermore, the company does not specify its standards: if larger males are or not discarded.

The GMM male also betrays, because, although it does not bite – and thus, do not transmit the disease for humans – it can propagate the virus among the female population. Hence, if a male OX513A mates with a wild infected female, it will contaminate all subsequent females it mates with (Consumers' Association of Penang; Sahabat Alam Malaysia, 2010, p. 17).

Another actor recruited by those who criticize the technology, are the surviving offspring of GMM and their wild partners. Again in an article written by Oxitec's researchers, they acknowledge that there is a 3–4% survival rate among the offspring of. They

> found no difference in the survival of LA513A/+ transgenics and their wild type siblings when reared in the presence of 30 μg/ml tetracycline, but in the absence of tetracycline only *3–4% of the transgenics survived from the first larval instar to adulthood*, compared with 86– 88% of wild type, a 95–97% reduction in survival relative to wild type [emphasis added] (Phuc, et al., 2007).

This point is once more not mentioned in Oxitec's campaigns (Consumers' Association of Penang; Sahabat Alam Malaysia, 2010, p. 18). An arguments of those pro-GMM, to determine the technology as possible to calculate and master – thus, a risk and not an uncertainty – is the possibility of, at any time, completely remove the GMMs from the environment. Nonetheless, the survival of genetically modified larvae could mean that this removal becomes impossible (International Civil Society Organizations (53), 2010, p. 2). From risk, it becomes an uncertainty: "it is *not clear* how the offspring of the male GM mosquitoes survive into adulthood and do not die as 'programmed', but it raises the possibility that they could breed and pass on this — as *yet unknown* — mechanism for overcoming the lethality" (Tan, 2010) [emphasis added].

To counter-argument against the concern rose by this “incomplete penetrance of lethality”, Phuc *et al* mobilize as ally the already long used SIT programs. They cite the work of H.J. Barclay (2001) who “concluded that moderate levels of non-sterility, e.g. 8%, would have little adverse effect” (Phuc, et al., 2007). The work of Barclay, however, is for conventional SIT technique, not RIDL[69].

Hence, GMM can only survive to adulthood in the presence of the antibiotic tetracycline. They produce an extra enzyme, which accumulates during the larvae to a level where it becomes toxic and deadly and tetracycline mops up the enzyme (Tan, 2010). In the Memorandum made to Malaysian authorities, the civil organizations the Consumers' Association of Penang and Sahabat Alam Malaysia pinpoint that

> tetracycline is widely used in Malaysia for medical, agricultural, veterinary and livestock purposes. Therefore, if the eggs are laid in an area exposed to this antibiotic, its offspring may live and we may end up having the offspring of GM mosquitoes loose in the environment (Consumers' Association of Penang; Sahabat Alam Malaysia, 2010, p. 32).

This is another example where an actor is mobilized to transform risk into uncertainty. Those in favor of transgenic mosquitos define tetracycline as what permits control over GMM – since it cannot survive without it. Concomitantly, critics mobilize the wide spread medical, agricultural, veterinary use of the antibiotic – thus, its presence in the environment – to re-define the identity of tetracycline, and enroll it, exactly as the actor which does not permit the calculability and mastery of GMMs[70].

Additionally, there is another betrayal from the ‘doomed heterozygotes’. The release of GMM would result in the presence of a large quantity of dead genetically manipulated larvae

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[69] If we remember the discussion on Chapter 3, this is another example of a substantial equivalence approach. They assess the non-sterility in comparison to the other SIT insects, and not as something new.

[70] If we go back to Chapter 4, this would be an argument to addopt the precautionary principle, since one of the main purpose of the approach is to avoid irreversible decisions.

in water. In the Press Release from ISIS (Institute of Science in Society), Cummins and Ho (2008) highlight it as another point of *uncertainty*, since the lethally

> has a *rather ill-defined action*. (…) Even though a *homologous tetracycline-repressed gene was not toxic to mice* upon its activation, the killing toxin in the mosquito should certainly be identified before released to the environment is contemplated (Cummins & Ho, 2008) [emphasis added].

Another controversy is the environmental equilibrium. Critics argue that eliminating the mosquitoes through the RIDL technique would create an ecological niche. On this paper we discussed *Aedes aegypti* but there is another species (from the same genus) that can also transmit the disease. The *Aedes albopictus* is originally from Southeast Asia, where is considered the main vector for dengue disease (Aguiar, et al., 2008, p. 358). In Brazil this mosquito was first recorded in Roraiama – North region – in 2006; however it is not acknowledged if it has been a vector for dengue in the country. It was claimed that

> Oxitec is developing a GM version of a second species of dengue-carrying mosquito (the Asian Tiger mosquito) because it is aware that this mosquito *could* occupy the ecological niche vacated by reductions in numbers of the first species it is targeting. This second species is more invasive and can carry more diseases (Consumers' Association of Penang; Sahabat Alam Malaysia, 2010, p. 2)

The *Aedes albopictus* presents itself as a strong ally for those condemning GMMs: it could worsen the situation in Brazil, since this mosquito would be more adaptable and a more aggressive biter (BBC, 2011). Conversely to the *Ae. aegypti*, the Asian Tiger mosquito can spread on urban and rural environments, and does not depend of large human concentration to survive. "Additionally it presents large ecological plasticity, evidenced by the capacity to colonize the most varied types of recipients, natural and artificial ones" (Aguiar, et al., 2008, p. 358). Although those defending the GMM admit this possibility, they (re)define the *Ae albopictus*' identity, allowing them to also recruit it as an ally. For them

> it is possible that controlling Ae. aegypti would allow some increase in the numbers or range of Ae. albopictus, though there seems to be little actual evidence for this. Since the result would be to replace the most severe vector with a less anthropophilic, less effective vector, such an outcome would

> likely represent only a marginal reduction in the net beneficial effect of controlling Ae. aegypti. *In some cases an SIT program against Ae. albopictus may well be desirable in any case, and this could certainly be combined with, or follow on from, a successful program against Ae. Aegypti* (Alphey, et al., 2010, p. 308) [emphasis added].

In a Brazilian newspaper report made about the transgenic mosquito, it was argued that this environmental unbalance could not happened in Brazil, since " the *Ae. Aegypti* is not native from Brazil and found an ideal environment here because it does not possesses natural predators" (Cristino, 2011)[71]. In an article, where some of authors are from Oxitec, this argument is also presented:

> *Ae. aegypti* is native to some parts of Africa but has been inadvertently spread around the world by humans in the relatively recent past. One would not therefore expect any native species in the Americas, for example, to be dependent on this vector species. Indeed, removal or suppression of an invasive exotic species might be considered somewhat desirable (Alphey, et al., 2010, p. 308).

Another mobilization made by critics of OX513A is the possibility of producing a 'genetic treadmill' that could be difficult to reverse (International Civil Society Organizations (53), 2010). GMM opponents highlight that it would require a continuous release of mosquitos on *substantial* numbers – as mentioned, Margareth Capurro predicts that for each wild male five to ten modified ones are required[72] (GeneWatch UK, 2010, p. 3). The releases should be done periodically, usually weekly[73]. This could create a constant dependency, tying the governments to costly payments. It is worth remembering that this is still a very expensive technology[74] (Mustafa, Bansal, & Rastog, 2011, p. 193), and the countries dealing with

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[71] This point was developed in the middle of an interview with Margareth Capurro. It is not clear, however, if she mentioned this or if it is an argument made by the journalist.

[72] It is recommended that 10^8-10^9 should be stockpiled for any given project (Atkinson, Su, Alphey, Alphey, Coleman, & Wein, 2007, p.9545).

[73] The argument behind the necessity of constant releases is that if "releases are of sufficient frequency, for example, weekly, to maintain a permanent standing population of sterile males in the target area, so that females seeking mates always have a high chance of mating with a sterile male" (Alphey, et al., 2010, p.298).

[74] Pro-GMM scientists respond to these critic by stating that "rearing insects may seem relatively expensive, at least when many millions may be required. However, this perception may not be correct. There is considerable accumulated experience of the costs and other issues around mass-rearing insects" (Alphey, et al., 2010, p.303). According to them the RIDL could be financially attractive in comparison with other existing options: they

dengue fever are usually poorer nations[75]. When asked about this topic in an interview, Luke Alphey from Oxitec replied, "it seems sort of universal in terms of vaccines, drugs or any kind of therapy" (BBC, 2011)[76].

Furthermore, "it has previously been reported that, in some such cases, an SIT program with an *insufficient* release ratio *could actually increase* the stable adult population; this prediction depends on assumptions that are not unreasonable for some mosquito populations" (Phuc, et al., 2007) [emphasis added]. This demands that the releases are made in great numbers, or there is a chance that the *Aedes aegypti* population can grow. Phuc *et al*, recruit the larvae – which had betrayed them – to once again become an ally. The competition during larvae, caused by OX513A's late-lethality, "could potentially help to offset the 'rebound' effect expected for mosquito populations in the early stages of a conventional SIT program, reducing the required release ratio, and hence the cost and sustainability of the program" (*ibid*).

Among those opposing to the GMMs there is a strong presence highlighting the uncertainty of this project, i.e. besides all the ones outlined, there are those we cannot neither calculate, predict nor yet conceive. Expressions such as "unleash *unintended* consequences", "*unpredictable* outcome", "too many *unknowns", "unintended* impacts", etc. are recurrent.

Besides downplaying the alerts made towards GMM, those who support the technology claim through different arguments the general idea that "benefits outweigh potential concerns"

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mention an unpublished "the costs and benefits suggest that the use of a RIDL strain against *Ae. aegypti* and dengue would be attractive relative to alternatives".

[75] In an article – in which some of the writers are Oxitec researchers – they mention this fact: "Many endemic countries do not have sufficient infra-structure and management experience to conduct a genetic control program. In the absence of *extensive outside support*, these countries will not be good candidates for genetic control programs (conversely, *with such support they would be, and there would clearly be a significant capacity-building component and outcome to such support*)" (Alphey, et al., 2010, p.300) [emphasis added].

[76] As we will see in the following chapter this matter becomes even more controversial due to Oxitec's troubling financial situation and the pressure from investor for the company to start commercializing the mosquitos project in order generate revenue.

(Alphey, et al., 2010, p. 306). Additionally, they uphold that “acceptable cost depends in part on an assessment of the alternatives” (Alphey, et al., 2010, p. 304). The scholar Martin Peterson, who mainly discusses medical trials, reasons in a similar thought of line. He recognize that it is impossible to foresee all outcomes, but that should not be an argument for precautionary measures. Since for him, knowledge cannot be obtained in other matter then trials, when “benefits outweigh the risks”, it “is important that tragic accidents should be accepted” (Peterson, 2007, p. 305). Thus, as we will again discuss in Chapter 5, the eminence of dengue as a problem is used to legitimate the risks/uncertainties and silence the debate around GMMs.

Chapter 5 - Discussing Beyond the Risks and the Uncertainties -

5.1 – A look at GMM's decision-making process

Besides the controversies around risks and uncertainties cited in the preceding chapter, there are other important issues that need to be brought into the discussion as well. One point is the real motivation behind the releases. According to the British group GeneWatch IK, Oxitec is facing financial losses and is under pressure to start generating income to repay investors:

> Oxitec made a loss in 2008 and 2009 of £1.7m a year: no dividends were paid to its investors. The company does not appear to have raised new capital since December 2009 and is presumably surviving based on the Wellcome Trust grant it secured to conduct the open field trials (GeneWatch UK, 2010, p. 5)

Hence, Oxitec's business model is also criticized. As stated in the former chapter the RIDL technology would require continuous releases. The model implicates locking customers – i.e., governments of countries dealing with dengue, such as Brazil – into recurrent ongoing payments. "Even if there are no adverse effects, releases of GM mosquitoes will need to be continual to avoid resurgence in the mosquito population" (GeneWatch UK, 2010, p. 6).

We reach, thus, another matter: accountability. In the Brazilian case there is no announcement on how much is being spent on the research and release of OX513A. As previously mentioned, RIDL is an expensive technology that requires a large investment to begin with. Furthermore, the project demands continual release. Although the mosquitos are being bred in Brazil, the British company has a patent over them, and must receive its royalties. These financial matters are nowhere to be found.

Another matter is liability. CTNBio has not defined what are the responsibilities of Oxitec, Moscamed or USP's researchers towards the local population in case something unplanned or wrong happens. As previously discussed in the Malaysian case – where liability and redress were not tackled by legislation either:

> Does it mean that Oxitec will get away scot free although it owns the patent rights to the GM mosquito? Who, how and where can the communities seek redress should any adverse health and environmental effects occur? Who will be held liable? (Consumers' Association of Penang; Sahabat Alam Malaysia, 2010, p. 33)

Aforementioned, all the GMM releases were marked by a lack of openness. In the Cayman Islands, Oxitec explained that the authorities had approved the trials[77] and the population was informed of them; but others argued that there were no town hall meetings or public debates over the issue (Enserink, 2010). The video posted by Mosquito Research and Control Unit of Grand Cayman (MRCU) – after the releases had happened – did not mention the insects were transgenic. It is also a concern that the trial caught the scientific community by surprise. As the British entity GeneWatch UK pointed out, "these are the first releases of GM mosquitoes anywhere in the world and have been conducted without proper public debate, ethical oversight or parliamentary or scientific scrutiny" (GeneWatch UK, 2010, p. 8).

In Malaysia there was some discussion in the media around the GMM, which triggered many opposing voices. Although some debate has happened, a memorandum send to the government criticized that

> there was no public forum where members of the community could have raised their concerns or sought explanation regarding the GM mosquito release from the authorities. Neither is the public informed as to what are the mechanisms whereby the communities at the release sites will be briefed, and how consensus and consent will be obtained. (Consumers' Association of Penang; Sahabat Alam Malaysia, 2010, p. 39)

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[77] "The Cayman Islands does not have any biosafety laws and is not covered by either the international Cartagena Protocol on Biosafety or the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, to which the UK is a party. These conventions would have required publication of and consultation on an environmental risk assessment prior to release. Instead, the only regulatory requirements were a local permit from the Cayman Islands Agriculture Department and a notification of transboundary movement of a GMO (the GM mosquito eggs sent by Oxitec to Grand Cayman) under Regulation (EC) 1946/2003. Neither of these documents appears to have been published. The UK Government has stated that this is a matter for the Cayman Islands and that the Foreign and Commonwealth Office (FCO) had no discussions in advance of the shipment of the GM mosquito eggs or their release" (GeneWatch UK, 2010, p. 9).

The OX513A mosquitos were released into the environment when they already had all the authorizations required by Malaysian legislation, but the general opinion seemed to be that the release had been postponed. Once again there seem to be a cape of secretiveness over the issue.

In Brazil, the media has barely mentioned the case. When it did, the GMMs were framed only as a promising technological solution, *choosing* to make only one side visible. It is interesting to note almost all news report made regarding the transgenic insects came combined with some worrying data concerning the (negative) effects of dengue in the country.

There is also the issue of transparency at the assessments made by CTNBio. Third parties can only be informed about the transgenic evaluations through the certificates issued by CTNBio, limiting the access of citizens and independent scientists (Terra de Direitos, 2011 b). In July 2010, the Federal Environmental Court of Curitiba[78] (*Vara Federal Ambiental*) ordered the Union, through CTNBio, to ensure "access to all interested parties of the full content of the documents requested, except only those that are granted confidentiality" (Campanha Brasil Ecológico Livre de Transgênicos, 2011, p. 7). They argued this right was guaranteed under Brazilian legislation.

Nonetheless, in August 2010, CTNBio, through his President, announced the Confidentiality agreement (*Termo de confidencialidade*)[79]. This forbade CTNBio's members to share information considered to be confidential, with "liability in civil, criminal and / or administrative spheres" (CTNBio, 2010). Those who refuse to sign it are prevented access to the process that has any confidential material. The concealment is not limited to sections that

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[78] Curitiba is the capital of the Southern state Paraná.

[79] The full version of the Confidentiality agreement can be seen on the minutes of CTNBio's 135th Reunion (CTNBio, 2010).

violate the companies' intellectual property. According to Leonardo Melgarejo, representative of the Ministry Agricultural Development in the committee,

> secrecy, by law, can only be assigned to parts of documents that threaten the economic interests of companies, information that would compromise aspects of competition between them, and they are justified and accepted as such by CTNBio (Valor Econômico, 2011) [80].

CTNBio, however, maintains secret even issues such assessment studies over health and environmental risks (Terra de Direitos, 2011 a). In the GMM case the proponent Margareth Capurro requested, for example, confidentiality on the areas where the mosquitos would be released, because to her, this could induce "public manifestations that would jeopardize the project evaluation" (Campanha Brasil Ecológico Livre de Transgênicos, 2011).

Hence, another matter is the amount of information the local population had access. Those promoting GMM argue that the population has been informed and supports the project.

In March 2011, Oxitec's Newsletter pronounced that

> Public engagement is key to the trials. Moscamed has already held a public workshop attended by key stakeholders such as national and local health officials, members of the public and the media. An ongoing programme of public consultation and engagement is being carried out in parallel with the trials (Oxitec Ltd, 2011).

Furthermore, at Moscamed Brasil's website a campaign made during Carnival this year is publicized:

> The Carnival block *Papa Mosquito* (Mosquito Eater) went trough the streets of the Massaroca District (BA), last Saturday (9), to raise awareness of the population on the key preventive measures to fight outbreaks of the mosquito *Aedes aegypti*, vector of dengue virus. / In partnership with Juazeiro's Municipal Health Secretariat (*Secretaria Municipal de Saúde de Juazeiro* - Sesau), Moscamed joined the event and distributed to local residents information about the Transgenic Aedes Project (PAT). The PAT aims to produce industrial-scale genetically modified *Aedes aegypti*

[80] This created an internal split in CTNBio. August this year, during the process to release genetically modified beans, CTNBio's President Edilson Paiva denied one of the members to look at the request before the agreement was signed. The voting was suspended and several members – supported by civil organizations – protested against the mandatory contract.

> mosquitoes, which will be released in the wild to control the wild populations of the dengue vector mosquito (Moscamed Notícias, 2011 b).

Nonetheless, reports made by civil organizations revealed that the trials happened without prior informed consent from the local population (Campanha Brasil Ecológico Livre de Transgênicos, 2011; Terra de Direitos, 2011 a). It is hard to judge over this matter with no fieldwork. It is relevant, however, that the head-researcher explains the choice of place due to the population already being used to insects' release. It is possible that the locals have not been well informed of the differences between the insects formerly released (sterilized by irradiation) and the transgenic mosquitos being freed into the environment now.

5.2 – The boundaries of a mosquito

Another point to be discussed is that Oxitec's mosquito, *Aedes aegypti* OX513A, is a patented *product,* a *living technology.* The first living organism – sometimes termed Living Modified Organisms (LMOs) to differentiate from other GMOs[81] – to be patent was a bacterium developed by Ananda Mohan Chakrabarty, while working for General Electric, to degrade crude oil. The patent of LMOs was not something obvious, given, but something that had to be (intensively) *negotiated*. Actually, at first stance, the United States (U.S.) Patent Office refused to consider patent applications on engineered living organism (Smith Hughes, 2001, p. 563). Nonetheless, the case reached U. S. Supreme Court and in June 1980 it was decided – in a 5-4 ruling – that modified organisms could be patented because they constituted a *manufacture* or *composition of matter*. Hence, "the justices ruled that Chakrabarty's microorganism was *not a product of nature* but, rather, a novel *invention* of his own ingenuity and thus patentable subject matter" [emphasis added] (p. 569). What was

[81] Although I will not further discuss this point, it is interesting to note that plants are perceived to have a different 'life status' than other organisms such as for example bacteria or mosquito.

being discussed was if LMOs belonged to *nature* – and could not be patented – or if they were a human invention, a scientific product – and, thus, belonged to *culture* and could be patented. Sally Smith Hughes (2001) describes part of this negotiation process, the many actors that had to be mobilized and enrolled in order to construct a certain network that framed LMOs as not belonging to nature, but to culture.

The case of living organisms helps us perceive that boundaries such as those that define what is natural and what is cultural are constructed. To deal with this issue, Donna Haraway (1991) introduces the notion of a *cyborg*, the entity of the confused boundaries. She pinpoints how, boosted by science and technology, three main boundaries have broken down. The differences between human and animal, *animal-human (organism) and machine*, and physical and non-physical are increasingly ambiguous (p.151). Thus, in the academic work and in political action, instead of deepening of dualisms, we should seek to embrace this blurriness of boundaries, and the cyborg is the ultimate expression of that: “so my cyborg myth is about transgressed boundaries, potent fusions, and dangerous possibilities which progressive people might explore as part of needed political work.” (p.154). She wishes to turn away from any essentialist differentiation – the cyborg is partial and in constant search for connections – and proposes a political and theoretical framework for “pleasure in the confusion of boundaries and responsibility in their construction” (p. 150).

Bruno Latour also explores these boundaries (or the lack of them), but does so not in terms of cyborg but of *hybrids*. In the book ‘*We have never been modern’*, Latour identifies two sets of practices that he considers to be distinguishingly ‘modern’. The first one is *hybridization,* which “creates mixtures between entirely new types of beings, *hybrids of nature and culture*” [emphasis added] (Latour, 1993, p. 10); and these hybrids are everywhere (p.11). At the same there is also *purification*, creating “two entirely distinct ontological zones: that of human beings on the one hand; that of nonhumans on the other” (p.10-11). Latour outlines what he calls a modern *Constitution* that "defines humans and nonhumans, their properties and their relations, their abilities and their groupings" (p.15). He argues that at the same time the moderns deny the existence of the hybrids, it is this attempt to separate, purify, which allows the hybrids to proliferate (p. 40). It is important to underline that to talk in terms of hybrids does not mean that there is no distinction between nature and culture. However this distinction is not something given, but the late result of stabilization (p.86).

The Constitution also creates a separation between scientific power and political power. The former is assigned to represent the things and the latter represents the people (p.29). In Latourian terms *spokespersons* are also designated. The politicians are seen as the spokesperson of the humans, which have a voice, but cannot all speak at the same time. And the scientists are the voice of the silent nonhumans. Latour points that when the representative of the people *translates* the many voices into one, it can also betray them; "traduttore-traditore, from translation to treason there is only a short step" (Callon, 1986, p. 214). The same can happen with the scientists and the nonhumans. Nonetheless, the representatives of the things try to make their translation invisible, portraying it solely as uncovering (Latour, 1993, p.28-30).

Kleinman and Kloppenburg (1991) while analyzing the discourse on biotechnology advertisements made by Monsato in the United States, also discuss the role of scientists. On their research, one of the discursive elements they highlight is the rigid separation between science and society, and the roles of those on the two spheres. Science belongs to the scientists, and they are seen as the only ones with competent and legitimate expertise to make decisions. Society should play a passive role, accepting the scientists' positions and judgments. Any resistance to technoscientific developments is classified as lack of knowledge or understanding. For example, Monsanto's chairman claims that

> the only thing that will stand in the way of our achieving the full potential of our next golden era is that we will be thwarted by a *public that doesn't understand science or technology and that doesn't trust us to use science wisely and with appropriate regard for the concerns of the public we serve*. We must double, redouble, and redouble again the amount of time and money we devote to educating the public (apud Kleinman & Kloppenburg, 1991, p.432)

On this perspective, any opposition to technoscientific progress can only be a result from ignorance or irrationality.

Ulrich Beck also points that the belief in technoscientific progress has permitted social change to happen without democratic examination and participation. "'Progress' can be understood as *legitimate* social change *without* democratic political legitimation. *Faith in progress replaces voting*"[82] (Beck, 2009, p. 214). The German scholar also discusses how this 'techno-scientific rationality', trapped in a 'narrow minded belief in progress' (p. 58), is also in the center of the proliferation of risks. Nonetheless, it is the production of those risks themselves that are weakening the blind quest for progress and profit (p.13, p.40).

Notwithstanding, Beck points out that social invisibility of the risk society. *Visible* life improvements – he mentions specially wealth, but in our case we can also relate to the possibility of better health – wins against the *invisible* risks. Those pro-GMM advertise it as a solution to a *visible* problem – dengue –, while those criticizing it can only talk of potential (*invisible*) risks.

Yannick Barthe (2009), while looking upon three different proposed solutions in the case of nuclear waste management in France, discusses around the impossibility to separate a technical decision from its political properties. This would be because

[82] It could be that 'progress' can even be more strongly mobilized in the Brazilian context. As mentioned, the positivistic ideas, which praise progress, were and are influential in the country. Additionally, Brazil, as a so-called emerging nation, relies in 'progress' to substantiate it as a (future) World power. Further research would be needed to outline the precise influence of these ideas.

> each one of these technical devices can be associated to a particular conception of political decision. Additionally, the passage from one device to another means much more than a simple technological reorientation: it corresponds to a profound transformation on the privileged modes of action in case of uncertainty (Barthe, 2009, p. 3).

We can take one step back and say that it is not only the technical devices that encompass a certain political perspective. The problem itself, how it is *framed,* and which solution is proposed – because of the framing – contains already a certain political viewpoint. To focus on the mosquito population as the main cause for dengue – and not bad quality of the primary health system, for example – and to propose a technological solution (GMMs) and not improvements on the health system or living conditions, is associated to a particular conception of political decision and worldview.

- Concluding Remarks -

We demand guaranteed rigidly defined
areas of doubt and uncertainty
Douglas Adams (Vroomfondel -The Hitchhiker's Guide to the Galaxy)

This work's purpose was not to draw a defense nor an accusation of GMOs, and more especifically the genetically modified *Aedes aegypti,* but to analyze and discuss the series of issues around the decision-making process under conditions of high uncertainty in Brazil and beyond. Nonetheless, I have tried to bring some symmetry – to an asymmetrical world – by outlining the diverse actors involved in the controversy.

In the attempt to bring some light over this controversy, I started by explaining some of the Brazilian peculiarities. The legal framework and the main actors involved in the controversies, what were their agendas and strategies. I analyzed the construction of the 2005 Biosafety Bill and the negotiations around it. As we saw, the characteristic of combining stem cells and transgenic under the same legislations, created specific new associations, mobilizations and group enrolments. It is interesting to re-take the notion of an exception regime: throughout this process, the Brazilian laws were systematically overlooked in name of an economic and scientific development.

On the second Chapter we turned our attention to dengue, this tropical arbovirus disease that affects millions around the world. For decades, Brazil has been trying to "fight" it with not so much success. The number of cases has been increasing in Brazil – and in the world – and I outlined some of the possible reasons for such tendency. The focus of policies in the South American country has been vector control – although some scholars argue that quality of primary health system could have a stronger influence than the population size of the mosquito. A new alternative has been developed by a British biotech company, and it is been tried out by Brazilian researchers. The genetically manipulated *Aedes Aegypti* technique promises to repress the vector population, through the release of so-called sterile GM males. Brazil was the third trial, and we briefly discussed how the other two – in Cayman Islands and in Malaysia – were executed.

Afterwards, I discussed two different guiding principles when making decisions around new technoscience matters: *substantial equivalence* and *precautionary*. I characterized each one, trying to bring forward which actors tended to endorse them. One point was who should have the *burden of proof*. Precautionary principle proposes that those trying to introduce a new technology or activity should be the ones who need to prove it is safe, not those claiming it is hazardous. We saw that in Brazil this does not happen, and those pro a faster liberation are allowed to give limited information about the new technologies that propose to implement.

On Chapter 4, I acknowledge two concepts, in an attempt to bring a new light in the GMM discussion: risk and uncertainty. For Ulrich Beck, modernity is moving towards a new phase characterized by reflexivity, and it is now turning its attention not only to the technoeconomic development, but also towards the risks produced by this very development. There is a heightened awareness that complete mastery is impossible, and that not all state worlds can be predicted nor imagined. Thus, another concept proposed is uncertainty, which incorporates the idea that knowledge (scientific or not) cannot be complete, and cannot predict and describe all conceivable alternatives, let alone the ones that are unimaginable. I thus introduce how risk and uncertainty are presented in the GMM case. I outline the main controversial points, which actors are mobilized and how identities are defined. We have seen how those who are in favor of the transgenic mosquitos talked only in terms of controllable and calculable risks. Concomitantly, opponents to the technology have done terms of predictable risks as well as unimaginable uncertainties. Those pro-GMM have de-politicized and silenced the debate, arguing that the benefits outweighs concerns.

Finally, I take the debate one step forward, trying to go beyond risks and uncertainties, and bringing forwards other important issues on the transgenic mosquito case study. I outlined issues such as the motivation, liability, accountability, information access, media participation, framing of the GMM, transparency around the evaluations, popular participation, etc. Additionally, the transgenic mosquito, as a *living technology*, helped us perceive the blurriness of boundaries. How the distinction between culture/science and nature is not something given, but negotiated and only defined as a product of stabilization. Another (constructed) separation discussed was the one between science and society. Scientists, supported by the idea of technoscientific progress, have demarcated their voice as the only legitimate one when dealing with issues related with science and technology, defining different opinions[83] as irrational or ignorant.

In case of GMM we have seen how a discourse of progress and the necessity to fight dengue, were used to depoliticize the issue. Risks and uncertainties were not openly discussed, assessments were kept secret, and the population was not involved in the decision-making process. The precautionary principle, public involvement, and other methods that rethink the quest for linear development are not against technology and science, but are "a salutary spur to greater humility[84]" (Stirling, 2007, p. 312).

> A move towards plural, conditional advice would help avoid erroneous 'one-track', 'race to the future' visions of progress. Such advice corrects the fallacy that scepticism over a specific technology implies a general 'anti-

[83] These 'different opinions' are usually categorized as 'resistance'. To put into such word is to already adopt a technological deterministic perspective, where technoscientific progress follows an inherent logic that is beyond the possibility of control by humankind.

[84] This is connected to Jasanoff's proposal of 'technologies of humility', where she request "humility, about both the limits of scientific knowledge and about when to stop turning to science to solve problems" (Jasanoff, 2007, p.33). For more information see Jasanoff, 2003.

> science' sentiment. It defends against simplistic or cynical support for some particular favoured direction of change that is backed on the spurious grounds that it is somehow synonymous with 'sound science', or uniquely 'pro innovation' (2010, p. 1031).

I expect after reading this thesis my interrogator will no longer wonder why a social scientists has turned her attention to a 'science and technology' issue. This piece of work has been an implicit and explicit criticize to the separation of society and science and the issues entangled on them. This distinction, allied by the belief of technoscientific progress – which only scientists can offer us – has been used to silent many opposing voices. Further research[85] will focus exactly on these issues of 'democratizing' technoscience, to propose academic and political discussion about these new arrangements and how to construct and be accountable for a technoscience that should be increasingly more *ours*.

[85] I am currently enrolled a new course, a Research Master on Cultures of Arts, Science and Technology, at Maastricht University, and continue on my research collaboration with the Spiral Institute, Liège.

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COECOCEIBA-Friend of the Earth Costa Rica; Doctors for Environment (Switzerland); Earth Savers Movement; Earthlife Arica eThekwini Branch (South Africa); Ecological Society of the Philippines; Ecologistas en Acción (Spain); EcoNexus (UK); Environmental Rights Action/Friends of the Earth Nigeria; ETC Group; Food and Water Europe; Food and Water Watch; Friends of the Earth International; Friends of the Earth (Spain); GeneWatch UK; GM-Free Cymru (Wales); GM-Free Ireland Network; GM Freeze UK; GM Watch; Institute For Responsible Technology (USA); JINUKUN Benin National Network for Sustainable Management of Genetic Resources; Living Farms (India); Mediatorin (MAB) / Mediation & Project Management Agrobiodiversity; Network for a GMO-Free Latin America (RALLT); Oakland Institute (USA); Partido Kalikasan (Philippine Green Party); Partnership for Clean Air (Philippines); Peruvian Association of Consumers and Users (ASPEC); Pesticide Action Network (Germany); Pesticide Action Network Asia and the Pacific (PAN-AP); Pesticide Action Network North America; Pesticides Action Network (Uruguay); Save Our Seeds (Berlin); Schweizerische Arbeitsgruppe Gentechnologie (SAG); SEATINI (South Africa); Southeast Asian Council for Food Security & Fair Trade (SEACON); Sri Philipinas (Philippines); Sunray Harvesters (India); Swiss Foundation for Development Cooperation (SWISSAID); Third World Network (TWN); Washington Biotechnology Action Council (USA) , 1-4.

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- Glossary of Acronyms -

ACE: *Agente de Controle de Endemias*; Endemic Control Agent

ACS: *Agente Comunitário de Saúde*; Communitarian Health Agent

ANT: Actor-Network-Theory

ASTMH: American Society of Tropical Medicine and Hygiene

BA: Bahia state

CONAMA: *Conselho Nacional do Meio Ambiente;* National Council of the Environment

CQB: *Certificado de Qualidade em Biossegurança*; Biosafety Quality Certificate

CTNBio: *Comissão Técnica Nacional de Biossegurança*; National Technical Commission for Biosafety

DHF: dengue hemorrhagic fever

DSS: dengue shock syndrome

EIA/RIMA: *Estudo de Impacto Ambiental / Relatório de Impacto Ambiental*; Environment Impact Study / Environment Impact Report

EMBRAPA: *Empresa Brasileira de Pesquisa Agropecuária*; Brazilian Agricultural Research Corporation

FAPESP: *Fundação de Amparo à Pesquisa do Estado de São Paulo*; Foundation for Research Support of São Paulo

Farsul: *Federação da Agricultura do Rio Grande do Sul*; Agriculture Federation from Rio Grande do Sul

GMM: genetically modified mosquitoes

GMO: genetically modified organisms

IBAMA: *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis;* Brazilian Institute of Environment and Renewable Natural Resources

IDEC: *Instituto de Defesa do Consumidor*; Institute for Consumers Defense

IMR: Institute for Medical Research (Malaysia)

LMO: Living Modified Organism

MAPA: *Ministério da Agricultura, Pecuária e Abastecimento*; Agriculture, Livestock and Supply.

MP: *Medida Provisória*; Provisional Act

MRCU: Mosquito Research and Control Unit

OECD: Organization for Economic Cooperation and Development

Oxitec: Oxford Insect Technologies

PAT: Transgenic Aedes Program (Programa de Aedes Transgênico) or Genetic Control of the Aedes Aegypti Mosqutio Program (Programa de Controle Genético do Mosquito Aedes Aegypti)

PRB: *Partido Republicano Brasileiro*; Brazilian Republican Party

PT: *Partido dos Trabalhadores*; Workers Party

R.R.: Roundup Ready

RIDL®: Release of Insects Carrying a Dominant Lethal

RS: Rio Grande do Sul state

SIT: Sterile Insect Technique; (in Portuguese - **TIE:** *Técnica do Inseto Esteril*)

STS: Science and Technology Studies

TRF: *Tribunal Regional Federal*; Federal Regional Court

U. S.: United States (of America)

USP: *Universidade de São Paulo*; São Paulo University

WHO: World Health Organization

- Acknowledgments -

I would like to thank the entire Spiral Institute team for welcoming in Liège, as well as their comments and suggestions. I specially thank Pierre Delvenne for accepting to supervise me, and for doing it so well.

I would like to thank my ESST professors for sharing their knowledge and lighting me in ways of STS.

I would like to thank University of Maastricht, which allowed my coming to Europe by awarding me the UM High Potential Scholarship.

I would like to thank *gezellig* Maastricht. The lack of necessity to use a car has not been taken for granted; being able to bike has been my best thesis-stress relieve.

I would like to thank my ESST fellows: each and every one of you, with your so diverse background has enriched me on my academic and personal life. Thank you for being such good companions through the turbulent paths of ESST and thesisland.

I would like to thank all my dear friends in Maastricht for their companionship during this year. You have brought joy to my European life, and manage to compensate for the horrible, horrible weather.

I would like to thank my beloved Brazilian friends and our virtual friendship. To feel *saudades* is to know you are in my heart.

I would like to thank my family, even though they were most of the time an ocean apart, they were helpful and supportive. A special thanks for *papai*, who once again helped me on my stumbling words. I even would like to thank them for their chaotic visits in the two final phase of this thesis: chaos can be a source of creativity. This thesis is the reason for my absences. I hope you understand it and think it was worth it.

And last, but not least, I would like to thank *Brasil*. Not only for unfolding itself to be such an intriguing case study but also for being my home. I did not know I felt so Brazilian…