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3

Multi-causal Relationships in their Socio-political Context

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FRAMING CAUSAL RELATIONSHIPS IN SCIENCE FOR POLICY

Identification of causal relationships has a lot to do with control. Understanding which phenomenon determines another increases the ability of human beings' to cope with their environment.

At present, scientists and philosophers have difficulties in specifying when a relationship between two events is causal (Pearl 2000). In epidemiology, different models of causality exist, which Vineis and Kriebel (2006) divide into two classes. The first is characterized by a linear monocausal pattern of explanation, based on the concept of necessary cause (that is, the disease does not develop in the absence of exposure to the agent). The second is characterized by the concept of causal web (that, a concurrence of different conditions is required to induce disease). A widely used multicausal model is Rothman's 'pie' mode, in which a sufficient causal complex (a pie) is represented by a combination of several component causes (Rothman and Greenland 2005). The disease appears when the pie is completed. Such multi-causality provides the opportunity for removing only one or a small number of factors for preventing harm (Gee 2003). Other causality models have been developed in epidemiology but they have many limitations, mainly related to the low degree of accounting for interactions between causal factors, to their dynamic character over time, and to the differences between individual and population levels (Valleron 2000; Vineis and Kriebel 2006). The usual scientific approach to untangling such complex cause–effect relationships is to isolate one possible causal factor by statistically accounting for all others (EEA 2005).

For distinguishing between a chance association and a true cause and effect, Sir Austin Bradford Hill (1965) proposed nine criteria, widely used by epidemiologists and tested in environmental risk assessment (Collier 2003): strength of association, consistency, specificity, temporality, biological gradient, biological plausibility, biological coherence, experimental evidence, and analogy. Only one of these criteria indisputably revokes a cause-and-effect hypothesis (that is, temporality).

In environmental studies, research of causal relationships has the advantage of being able to test the experimental evidence in the laboratory, in controlled conditions. However, in natural systems, many factors may interfere with the researcher's ability to assess causality: the multitude of toxicants, their interactions with non-contaminant stressors, and the high biological variability. Furthermore, effects issued from different stressors might not be comparable and their synergic or antagonistic interactions make their combined effects to be greater or lesser than the sum of their individual effects. These gaps in knowledge add to those concerning compensatory processes that influence population dynamics, to the general lack of data, and to the difficulties associated with communication between several disciplines (Munns 2006). Moreover, assessment may concern several groups of organisms, at different levels of organization, and with different patterns of response to stressors. To date, there is no widely accepted and proven approach for establishing causality in natural systems (Collier 2003) or for dealing with multi-causality.

A simple conclusion that may be drawn from the above is that multi-causality is actually inseparable from uncertainty. Therefore, an aspect that has to be dealt with is the relevance of this uncertainty for action. How do people take decisions and what are the patterns of interaction between science and policy in conditions of uncertainty?

For dealing with the relatively new situations of hard political pressure, disputed values, high decision stakes, and major epistemological and ethical system uncertainties, science is called upon to answer with new practices. Funtowicz and Ravetz (1993) coined these emergent scientific patterns 'post-normal science', whose main features are the appropriate management of uncertainty, acknowledgment of the plurality of problem perspectives, and the extension of the peer community to include non-scientific actors.

The dominant belief in science for policy inquiries is that inappropriate control of environmental risks is due only to insufficient scientific knowledge. However, this ignores both the socioeconomic influence on the construction of the scientific evidence and the influence of political contexts on the use of such evidence for communication and action. Stakeholders can strategically use science in public debates (Hellström 1996; Van der Sluijs 2006). In some cases, the existence of contradictory expertise can be the result of a 'manufactured uncertainty', which is intended to favour the settling down and prolongation of the debate (Michaels 2005; Maxim and Van der Sluijs 2007). The consequence is mistrust, conflict, and low chances for mutually respectful dialogue among interested parties.

The extended quality control through broad participation of the stakeholders involved is proposed by post-normal science as a method for increasing the quality and acceptability of the risk assessment process and of its outcomes, and is embedded in the 'extended participation' model (Funtowicz 2006) of science and policy (see Overview by Guimarães Pereira and Funtowicz in this volume). Reducing the potential of conflict associated to mistrust is one of the results intended. Interested and/or affected parties may lack technical expertise but might have essential information and often hold strong views, which have to be considered in any democratic society (Kloprogge and Van der Sluijs 2005). However, the stakeholders' involvement process needs very careful architecture, as the quality of the process itself and the openness of participants to compromise are crucial for the outcome (Renn 1995).

The following case study is an exemplification of the need for post-normal science in case of contested (multi)causal explanations of environmental risks. First, we assert that the articulation of a particular causal link has, beyond its scientific basis, a social dimension that is strongly influenced by the actors' stakes. In the following, we compare two parallel processes of constructing knowledge for decision making with regard to the influence of socio-economic context on each and their respective consequences for policy. For this, we use the discourse analysis framework proposed by Hajer (1995). For him, the discourse coalitions that form around causal explanations ('story-lines') are meant to represent a particular definition of the environmental problem, on which the decision making critically depends. Second, the case presented below represents the first application of the precautionary principle in France, for an environmental issue. What were the conditions and the consequences of applying the precautionary principle are analysed below. Third, we expand on what should not be done regarding stakeholders' involvement. The chapter concludes by examining how key elements of post-normal science have been reflected in the process(es) of knowledge construction.

Social Ingredients of Causal Relationships: The Case of Honeybee Colonies Decline in France

The problem

In 1994–6, French beekeepers first noticed symptoms that they had never previously observed: in several days of sunflower foraging, honeybee populations were suddenly and massively falling. The foraging honeybees almost completely disappeared from the hives or, sometimes, found were dying by the thousands in front of the hives. These mortalities were accompanied by behavioural symptoms (trembling honeybees and forming of moulds in front of the hives) and by a 30–70 per cent loss in sunflower honey yield (GVA 1998–2006). High honeybee losses were also seen during the winter or in early spring. Given the novelty of the symptoms with regard to their previous experience, beekeepers tried to find if a new element had appeared in the environment of the hives or if previously known factors had changed patterns. It was communicated to local farmers that a new insecticide, Gaucho®, was first used in sunflower seed-treatment also in 1994. This was the first from a new generation of insecticides, applied on the plant not by spraying, but in seed-dressing, which dispersed to all plant tissues during the plants growth. Since the symptoms were particularly recorded for bees foraging sunflower crops and beekeepers learned from farmers that many of these were treated with Gaucho®, the beekeepers suspected there to be a toxic effect of this insecticide on the honeybees. Consequently, they asked Bayer, the producer of the insecticide, to inform them about its potential toxicity for honeybees. This was the start of a long series of scientific studies involving experts from Bayer, the Ministry of Agriculture, beekeepers, and independent researchers. Many of the studies of independent researchers yielded arguments supporting the causal link with seed-dressing and Gaucho®, whereas all the studies undertaken by Bayer during this period reported that Gaucho® did not form a risk for honeybees. The symptoms continued to be observed year after year and the economic status of many beekeepers was severely affected. Despite the initial statement of Bayer that the active substance was not present in nectar and pollen at the flowering time, imidacloprid was found by researchers in both. The combination of findings obtained by independent research, social pressure, and media attention led to the first application of the precautionary principle for an environmental issue in France. In 1999, the Minister of Agriculture ordered a two-year ban on the use of Gaucho® in sunflower seed-dressing. This ban was renewed in 2001 for two years and again in 2004 for three years. Because the symptoms continued to be observed even after this year, two more hypotheses were raised: (i) honeybees were still being exposed to the pollen of maize treated with Gaucho®; and (ii) imidacloprid persisted in the soils, i.e., the chemical was present in untreated crops growing in soil on which a seed-dressed crop had been grown one year earlier. Furthermore, another insecticide quickly replaced Gaucho® in sunflower seed-dressing. This new product, called RégentTS® (active substance: fipronil) was owned by BASF.

Discourse Coalitions

During the debate, all stakeholders acknowledged the influence on honeybees of several factors at the same time. However, the balance between the role of Gaucho® and the role of other causes has been framed differently according to the different stakeholders.

The debate on causal relationships can be structured around three story-lines. The first story-line is represented by beekeepers and independent researchers. Based on field observations and experimental evidence, they claim Gaucho® to be the main, if not sole, contributor for the damage caused to honeybee colonies observed after 1994 in sunflower/maize extensive crops areas (even if not the only contributor to all the honeybee problems in France). Their arguments built upon the results of numerous studies made in France after 1997 on the effects of imidacloprid on honeybees.

The second story-line argues for a non-causal relationship between Gaucho® and honeybees, articulating that other causes are to blame. This view was represented by Bayer and generally by the French Food Safety Agency (AFSSA). Their argument builds on the 'lack of evidence of harm' in their research carried out in controlled conditions of access of honeybees to food containing imidacloprid or in field conditions, whose results did not reproduce the symptoms observed by beekeepers. These two actors proposed several potential causal factors, including genetic origin of imported queens and low adaptation to local conditions, unfavourable climatic conditions, honeybee diseases and viruses, inadequate or illegal use of pesticides and mixes of pesticides by farmers, an insufficient quantity of pollen, and changes in sunflower strains.

Finally, the position of the Ministry of Agriculture was ambiguous, considering Gaucho® as one possible cause among others, with unclear contribution on the final effects.

The Socio-economic Stakes

For Bayer, the new generation of systemic insecticides used in seed-dressing represented an important opportunity for changing production patterns. Moreover, insecticides containing imidacloprid had a large international market.

Results for the honey yields published by the Coopérative France Miel for Western France showed the year 1995 as the starting point for the abnormal losses. The sector passed through difficult times, as nearly 15,200 beekeepers left this occupation between 1994 and 2004 (most of them were small producers).

The Ministry of Agriculture, confronted with contradictory demands from the two sectors, had a hesitating attitude. The main stake was to defend its legitimacy, given that the debate on Gaucho® revealed important dysfunctions related to the process of authorization of pesticides. Thus, in a letter published *Le Point* journal on 21 November 2003, the Head of the Bureau of Regulation of Anti-Pest Products (DGAL) described its lack of capacity as follows: 'three public servants for dealing with 20,000 demands of authorisation per year, a joint management of the risk assessment with industrials, lack of transparency in the procedures…it is impossible for the bureau to comply with its missions'.

The Research

Starting with 1994, the symptoms described by beekeepers were confirmed by different local or regional state services, documents produced by beekeepers for communicating their problems (GVA 1998–2006), and several research reports. The use of Gaucho® in sunflower/maize seed-dressing was found to be a necessary cause (without which the symptoms do not appear) for the lethal and sublethal symptoms, because the symptoms were very characteristic (never seen before 1994) and no other cause among all those investigated could explain the specificity of these symptoms for sunflower flow or their novelty. A second reason for having considered Gaucho® as being a necessary cause is that in its absence, beekeepers found that the same symptoms were not appearing (e.g., hives from the same apiaries placed in the forest during the same period of the season were behaving fine). The other factors potentially having an influence were found to be present all over the year and not only in areas of extensive cropping, without producing the set of symptoms observed. The use of RégentTS® brought an additional symptom, meaning intoxications during the spring sowing (the active substance was depositing with the dust spread during sowing on wild plants which were foraged by honeybees). Significant honeybee' mortalities were signalled in 2003 in these conditions.

The first indications of reframing the issue of honeybee colonies decline as a multi-causal one can be traced to January 1999, when the Ministry of Agriculture announced an epidemiologic study intended to determine the other factors that could have contributed to the honeybees' problems, along with the ban on the use of Gaucho® in sunflower seed-dressing.

The first monitoring study based on an 'all symptoms and all factors at the time' ('multi-factor') approach was carried out by AFSSA in 1998–2001, producing only very vague results. In 1999, the results of another study of AFSSA were not considered relevant because of the lack of data representativeness (Faucon 1999).

In 2000, a booklet meant to argue for the multi-causal origin of honeybee colonies decline found in France was brought out by Bayer. Based on the statement that the 'mystery of the "disappearing disease" in France has not been solved', the main arguments of the booklet pointed towards 'the many diseases to which bees are prone' and more generally towards 'the various causes of the bee problem' (Jacobs et al. 2000, p. 8). Beekeepers replied under the title 'The art of seed-dressing and of making fools of us' by pointing out the disproval of the discursive practices employed in Bayer's booklet: selective use of information, tendentious interpretation, absence of critical approach regarding the knowledge available on the risks of Gaucho® for honeybees, lack of rigour.

Some attempts to survey honeybees' intoxications were made in 2000 by the National Centre for Beekeeping Development (henceforth CNDA) within which the DGAL (General Directorate for Food, from the Ministry of Agriculture) engaged only formally (financing promised has not been not accorded). A monitoring network in which the DGAL really participated was not started until August 2002 (eight years after the start of the debate and three years after the Minister's announcement regarding the creation of a monitoring network). In 2002–3, four monitoring networks superposed. For each of them, the definition of 'honeybees' problems' was different, referring to honeybees' diseases, to 'general' problems encountered by honeybees, respectively to intoxications. Their spatial coverage was also different. Most monitoring survey was based on calls from beekeepers (when problems arose) and on confirmation by sanitary agents (trained persons approved by the State). However, in many cases the sanitary agents arrived too late to confirm the symptoms. Moreover, in the cases of disappearance of honeybees from the hive, the symptom could not have been confirmed without trusting the beekeeper who had actually observed it.

From all the existing monitoring studies and networks, neither a clear description of field symptoms nor a coherent analysis has been produced. These exercises were neither peer-reviewed by researchers nor had relevance for decision making.

Being directly interested in monitoring the symptoms in order to see their problem acknowledged and solved, beekeepers had proposed in 1998 to use the Vendée department (one of the most affected) as an experimentation field resembling real-life conditions. During that time, confronted with the ambiguity of successive surveys, they stepped back and felt the initiatives of field monitoring to be illegitimate and intended to bring confusion and prolong the debate. The passing of each year meant important losses for them, whereas the protocols of the multi-factor studies had low consideration for their description of symptoms. Beekeepers criticized the 'paralysis by analysis' and the diversion of the research towards too 'complex' subjects.

Seed-dressing insecticides have a high toxic activity at very low doses. Over the precision of analytical methods for measuring low exposures was several years refined for reaching very low detection and quantification limits. This allowed precise measures of imidacloprid and fipronil in the nectar and pollen of sunflower and maize. Simultaneously, methods for assessing the sublethal and chronic effects of imidacloprid and fipronil on honeybees were developed in the laboratory. The values found for exposure in the field were comparable with the values found for negative effects in the laboratory. In 2003, field experimentations made an explicit link between fipronil used in seed-dressing and honeybee' mortalities during spring sowing.

In 2001, an interdisciplinary expert group called the Scientific and Technical Committee for the Multifactor Study of the Honeybees Colonies Decline (CST), comprising 19 experts, was set up by the Ministry of Agriculture. The CST decided to start by carrying on the study of Gaucho®, because this was the most socially and politically sensitive factor among all those potentially involved. In the same time, the CST proceeded to the survey of honeybee problems in the field and envisaged effects of other factors (that is, other types of intoxications, honeybee diseases, etc.). In 2003, the CST published its final report on the risk of Gaucho® for honeybees (CST 2003), based on the detailed study of the 480 documents available. Temporal and spatial correlations between symptoms and sunflower/maize flowering led to focusing on these two crops, which were representing 'the problem' invoked by beekeepers. The CST agreed on criteria of quality for the studies and their results. These favoured transparency and allowed their comparative assessment. Their report published in 2003 was well organized and the methods and results were clear. It gave recommendations for continuing the study of the other factors involved and was approved by all the members of the CST. This report produced the first clear conclusion in the history of the debate, namely that the risk of Gaucho® for honeybees is worrisome, both in sunflower and in maize seed-dressing. A second assessment, which came one year later, confirmed the risk of RégentTS® on honeybees.

The Application of the Precautionary Principle

The case of honeybee colonies decline was, at the beginning of the debate in 1994, a 'perfect case of post-normal science', in which uncertainty and stakes were high and in which values were in dispute. The interactions between stakeholders started under good signs, through several meetings bringing all of them 'around the table', in 1995–7. However, the situation degraded slowly, along with the progressively disappearing mutual trust. This can be attributed to several factors. First several times the scientific evidence provided by the two companies was found to lack scientific quality and was contradicted by findings of independent researchers. Despite this, regulatory decision-making (i.e., authorization for marketing) relied exclusively on evidence coming from the industry. This led to doubts both on the reliability of the information on risks produced by the company and on the role of the State. A second reason was the absence of an 'arbiter' able to mediate the relationships between actors. The legitimacy of the Ministry of Agriculture was contested both by beekeepers and by chemical companies, the former suspecting policy of partisanship in favour of the industry, while the latter was suspecting decision-makers of weakness. The position of the Ministry in the debate was systematically confused, contradictory, and opaque. This changed the perception of the State from being the traditional provident 'social peace-maker' into being an actor as any other, with its own interests. Consequently, stakeholders felt abandoned to their own ability of defending their interests.

The debate embodied not only high political stakes, but also ethical values, related to the definition of democracy, the power of the State to control economic interests for protecting its citizens, and to the moral responsibility for the protection of the environment. The beekeepers received support from the civil society also because their case was relevant for larger preoccupations in the French society, such as the right to contest priority to be given in decision making to the criterion 'economic weight' to the disadvantage of 'equity'. Furthermore, the cultural and symbolic connotations of the honeybee contributed much to the public sympathy regarding the decline of apiaries.

By applying the precautionary principle and banning Gaucho® for sunflower seed-dressing, the Minister of Agriculture tried to make a compromise between the economic stakes for Bayer (only 10 per cent of the benefits issued from selling Gaucho® were obtained from use on sunflower), the economic stakes for beekeepers, and the socio-political context reflected by the press. This decision calmed down the conflict for the moment and boosted investigations on the effects on honeybees of RégentTS® and of Gaucho® used in maize seed-dressing. However, further political action proved to be much more difficult. The surface cultivated in France with sunflower comprised only about 40 per cent of the surface cultivated with maize, which represented, therefore, a much more important market opportunity for Bayer. The decision of banning Gaucho® in maize seed-dressing did not come until very late, in 2004.

After the ban of the two products, the social tension diminished and beekeepers recorded positive effects on their honeybees. In 2005, the honey yield, despite the negative influence of the hot summer, started to improve progressively. Sudden depopulation during sunflower and maize flowerings has not been observed anymore

(Clément 2005). Recent reports indicate that the situation of apiaries was good in the early spring of 2007 (Clément 2007).

Given the inadequacy of the available testing procedures for assessing the risks of new generations of insecticides on honeybees, acknowledged during the debate, a group of honeybee experts was appointed by the French Ministry of Agriculture, with the mission to develop new tests for honeybees. In 2006, a new unit was created at the AFSSA, responsible for risk assessment, while risk management continues to be the responsibility of the Ministry of Agriculture. The questions raised today relate to whether enough independence and resources are allocated to this unit for assuring its good functioning, and whether the choice of experts will allow a non-biased appreciation of the potential risks for honeybees.

Following the public acknowledgement of the role of the honeybee as pollinator and bioindicator for the environment, a 'Honeybee, sentinel of the environment' programme was initiated by the (National Union of French Beekeepers (UNAF), a syndicate representing about 22,000 beekeepers. The coverage of the case in the press also showed the importance of a partnership between beekeepers and farmers and raised consciousness among them.

Concluding Remarks

The analysis of the two processes of building knowledge on honeybees' problems shows the relevance of post-normal concepts of knowledge quality assessment and of involving the interested parties for contributing to informed policy decisions and for dealing with conflicting situations.

The multifactor approach had not provided answers to scientific or social purposes. The knowledge production was dealt with as being a general process of understanding the situation of honeybees in France, because it considered all the potential symptoms and all the potential factors indistinctively, instead of addressing the very particular problem of societal concern (honeybees' symptoms related to sunflower and maize crops). This 'general' approach could have been appropriate for an investigation in 'normal' conditions, but it proved to be inadequate for such a conflicting case in which research and decision needed to be quick and targeted towards limiting a specific harm. The monitoring schemes were implemented too late, when the relationships between beekeepers and the DGAL were already marked by profound mistrust. This led to low interest of beekeepers in monitoring, which they suspected of being only a tool for the DGAL for seizing the subject and legitimizing decisions already taken.

Beekeepers' involvement had an instrumental view, in which they would have provided automatically the knowledge that experts (DGAL, AFSSA) wanted for telling the beekeepers back as to 'what is wrong'. But beekeepers had their own capacity of expertise, which was not technical but which arose from their everyday experience with honeybees, and thus already had views on 'what is wrong'.

Independent researchers focused on assessing the exposure of honeybees for the two crops that constituted 'the problem', viz. sunflower and maize, and on understanding the symptoms described by beekeepers. For the researchers involved in the CST, the main resources for dealing with the social conflict were their competence and their commitment for transparency. During its work, the CST invited interested parties to communicate on their experience. Thus, it assured the scientific quality of the knowledge produced (through reviewing and validation of available studies) and its social relevance.

The most sensitive point in dealing with complex issues is not how to describe complexity as such, but how to choose the right manner to simplify it for decision making. As Hewitt et al. (2003) suggested, for some situations it may not be necessary, nor affordable, to attempt to determine precise causality. The level of investigation needs to be established with inputs from stakeholders (EEA 2001) from the very beginning of the research. This process of building the knowledge as a 'hybrid' presumes negotiations of each one's responsibility in the problem (Wynne 1996), enriches the assessment with information that can positively contribute to the results, and represents a democratic exercise of arrangement of (possibly) unbalanced power relationships through argumentation and expression of value diversity rather than through addled conflict.

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