creates a tautology. Clearly, an independent measure is critical so that the question "what is the effect of attractiveness on RS?" can be asked, and hypotheses about function can be tested. Thissen and Martin's suggested "free-choice" design, wherein birds could interact freely, has not proved feasible because the intense intrasexual competition generated swamps the choice process. While not all aspects of this methodological problem have been worked out, we have data (*1*, *12*) that attractiveness can be measured prior to pair formation without physical contact between participants.

The finding that "attractive" females are less successful reproductively than "intermediate" females is intriguing. One possible reason for this result has been discussed (*3*). Attractiveness is only one of several components affecting RS in polygynous and promiscuous species (*13*); its role in monogamous species is hardly understood. Understanding its importance requires information on the effect of attractiveness on several aspects of reproduction, including timing, frequency of breeding, eagerness to breed, the "willingness" of individuals to invest in their offspring (*14*), and the behavioral complementarity of various pair combinations.

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2. K. Immelmann, J. P. Hailman, J. R. Bayliss, *Science* **215**, 422 (1982).
3. N. Burley, *ibid.* **211**, 721 (1981).
4. They were denied opportunities to reproduce by isolation in unisexual groups as sexual maturity approached.
5. At the end of the 9 months for which data were reported, the population size was approximately 120, including about 20 juveniles, most of which were removed at a later date.
6. K. Immelmann, *Zool. Jb. Syst. Bd.* **90**, 1 (1962); *Australian Finches in Bush and Aviary* (Angus and Robertson, Sydney, 1974).
7. "Pseudomale" and "pseudofemale" behaviors have been described for heterosexual zebra finches by D. Morris [(*8*) and *Behaviour* **8**, 46 (1955)]. I have not previously observed homosexual pairings in zebra finches, although they do occur in low frequency in other monogamous avian species [pigeons (*Columba livia*), personal observation and W. M. Levi, *The Pigeon* (Levi, Sumter, 1974), and gulls (*Larus* spp.), J. P. Ryder, *Proceedings Colonial Waterbird Group* 1978, p. 138; ——— and P. L. Somppi, *Auk* **96**, 1 (1979)].
8. D. Morris, *Behaviour* **6**, 271 (1954).
9. Individual recognition is commonly effected by banding birds with unique color combinations. However, in this study there were at least ten birds of each color type in the aviary at any one time.
10. D. Thissen and E. Martin, *Science* **215**, 423 (1982).
11. The below average clutch size is consistent with the suggestion (*3*) that sex-ratio manipulation occurs postzygotically (and probably after hatching).
12. Unpublished data (N. Burley) indicate that preferences displayed in experiments are sex-specific. For example, males given choices among males wearing red, orange, or green bands show very different responses than females choosing among such males.
13. For example, R. A. Fisher, *The Genetical Theory of Natural Selection* (Clarendon, Oxford, 1930); G. Borgia, in *Sexual Selection and Reproductive Competition in Insects*, M. S. Blum and N. A. Blum, Eds. (Academic, New York, 1979), p. 19.
14. R. L. Trivers, in *Sexual Selection and the Descent of Man, 1871–1971*, B. Campbell, Ed. (Aldine, Chicago, 1972), p. 136.

5 November 1981

Cancer in Nickel-Processing Workers in New Caledonia

It appears to us that the hypothesis advanced by Langer *et al.* (*1*) is very weak and unsubstantiated when brought under close scrutiny.

1) The study by Lessard *et al.* (*2*) referred to in (*1*) does not present conclusive evidence with respect to the toxicity of nickel. As Maheux *et al.* point out (*3*), "this study [Lessard *et al.*] is by no means the final evidence that nickel (ore) dust is carcinogenic for human beings." Numerous criticisms can be made of this work, most of which were raised by the authors themselves. These include the following points: (i) There is no distinction made between primary and secondary cancers. (ii) A comparison is made between the incidence of lung cancer in New Caledonia and that in the rest of the world, which is based on data from the period 1970 to 1974 for New Caledonia and 1960 to 1964 for the rest of the world. It is known that the risk of mortality from lung cancer has risen over the years in developed countries. Between the period 1960 to 1964 and the period 1970 to 1974, the increase in the incidence was sufficient to place the European population of New Caledonia on the same level as the European population of New Zealand (where there is no nickel mining industry). (iii) The control group that was used is not representative of the population of New Caledonia and must therefore be considered with extreme caution. This group was selected from among hospital laboratory outpatients. As Maheux *et al.* admitted (*3*), "Some consequences of this, like a significant different mean age between the case group (58 years) and the comparison group (46 years) is of critical importance, even though the statistical method employed permitted to control for age." Furthermore, the proportion of smokers among the nickel workers in the control group (90 percent) is very different from what appears in our medical records (56 percent). (iv) Specificity with respect to nickel as the causative factor is missing.

2) The incidence of lung cancer in New Caledonia has remained practically unchanged over the past 10 years, although there was a considerable increase in medical monitoring and an increase in the level of nickel production from 1945 to 1975, and despite the fact that the incidence of lung cancer has increased significantly throughout the world (*4*).

3) The numbers of nasal sinus cancers, the incidence of which has been reported to be as much as 600 times higher in nickel workers according to epidemiological surveys related to "nickel smelters," have been very small thus far in New Caledonia, although nickel has been mined and smelted on the island for a century.

4) Only three cases of pleural mesothelioma were recorded in New Caledonia between 1970 and 1980 (*5*, *6*), and none of these among smelter workers. In our opinion, it is not possible to conclude one way or the other about the normality or abnormality of mesothelioma occurrences in New Caledonia. If, in fact, the inhalation of asbestos fibers had been an important factor in New Caledonia, a large number of cases of asbestosis should have been observed. The results of a complete standard detection program carried out in June and July 1980 on all personnel at a mining center on the island showed no significant anomalies that could result from exposure to asbestos, notably no pleural plate, pleural thickening, or pulmonary fibrosis (*5*).

5) Ores mined in New Caledonia result from the transformation by surficial weathering of ultrabasic rocks which are more or less serpentinized. These ores correspond to soft material which surrounds hard cores of fresh rock. When serpentinized, the fresh rock contains two magnesium silicates, lizardite and chrysotile, which is fibrous. In the course of weathering, the chrysotile disappears. The newly formed magnesium silicates are predominantly a nickeliferous lizardite (plane sheets) (*7*). As a result, the fines, the part of the ore liable to produce inhalable dust, contain only small, in fact very small, amounts of chrysotile (a few hundred parts per million). Thus, the amount of fibers inhaled by nickel workers is much lower than the minimum amount established by French law and also lower than the amount currently urged as a standard (less than 0.5 fiber per cubic centimeter).

Our investigations do not lead us to support the thesis of Langer *et al.* or to suspect that the nickeliferous substances (whether associated with chrysotile or not) that are handled in New Caledonia are responsible for most of the

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cases of lung cancer that have been observed among people in contact with these substances.

We believe, however, that the problem of lung cancer is of sufficient concern that dust emissions and the attendant hazards of all dust emissions require careful scrutiny. Société Métallurgique Le Nickel–SLN has created a special department to deal with this problem.

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2. R. Lessard, D. Reed, B. Maheux, J. Lambert, *J. Occup. Med.* **20**, 815 (1978).
3. B. Maheux, R. Lessard, D. Reed, "Epidemiology of lung cancer in New Caledonia" (Report to the South Pacific Commission, Noumea, 1977), unpublished.
4. This statement comes from a comparison of information contained in (*3*) with data from the Bureau of Statistics for Oncology Data of New Caledonia, which was established in 1977. In (*3*) the number of cases per year is given as follows: 1970, 7; 1971, 12; 1972, 21; 1973, 26; and 1974, 26. Data from the New Caledonian Bureau of Statistics is as follows: 1977, 16 to 17; 1978, 34; and 1979, 23.
5. P. Herzog and J. Meininger, "Mesotheliomes et cancers du poumon en Nouvelle-Caledonie" (1980), unpublished.
6. M. Charpin, "Communication from the Bureau of Statistics for Oncology, Noumea, New Caledonia," *Third Symposium: Epidemiology and Cancer Registries in the Pacific Basin, Maui, Hawaii, 19 to 23 January 1981*, in preparation.
7. G. Troly, M. Esterle, B. G. Pelletier, W. Reibell, in *International Laterite Symposium* (American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 1979), pp. 85–119.

15 May 1981; revised 13 July 1981

Five years ago, the International Metalworkers' Federation sought our assistance. They were concerned that members of their union at a nickel smelter in Noumea, New Caledonia, were experiencing an unusual frequency of lung cancer. Their apprehension was based in large measure on reports that excess lung and sinus cancers had occurred in workers in other nickel smelters in many industrialized countries, including Great Britain, Canada, Germany, Norway, and the U.S.S.R. (*1*). Although nickel mines, and later a smelter, had been in operation in New Caledonia for approximately a century, no health data had been reported (*2*).

The first health data from New Caledonia in 1978 indicated an increased incidence of lung cancer (*3*). Meininger *et al.* question this epidemiological report. We will leave its defense to the investigators except to note that any discussion of cancer rates in South Pacific populations is replete with statistical difficulties of case management, ascertainment, reporting, and recording (*4*). The essential question is whether the nickel workers there have a significantly greater incidence of cancer than their compatriots not so exposed. Studies that might shed light on this question have not been carried out. This is unfortunate, since, if there is no increased incidence of cancer in workers at the smelter in New Caledonia, as Meininger and his colleagues propose, it would be very important to study this anomaly in order to clarify why there is an increased incidence of cancer in workers at other similar nickel smelters.

It was against this background that we began investigating the New Caledonia situation. We are seeking etiological factors since studies on similar smelters had suggested that no single factor could account for the occurrence of all "nickel-associated cancers" (especially lung cancer). In a careful analysis of the question, E. Mastromatteo, medical director of the International Nickel Company, noted that some investigators had observed that cancer incidence was correlated best with the overall dustiness in a smelter (*5*). There have also been reports from metal recovery operations elsewhere, in which the host rock itself, being mined for specific commercial metals, also contained hazardous minerals, for example, crystalline silica (quartz) in gold mining and fibrous rock-forming silicates in iron-ore mining (*6*). That a similar situation might exist for nickel ores on New Caledonia was possible, especially since the saprolitic ores worked there included serpentine minerals, from which chrysotile asbestos fibers could be liberated.

With our colleagues in the Department of Mineral Sciences at the American Museum of Natural History, we examined Noumean nickel ores in the museum's collection as well as other specimens brought directly from New Caledonia. We detected the presence of submicroscopic chrysotile asbestos (*7*). Indeed, reports by the geologists of Société Métallurgique Le Nickel–SLN had already noted this (*8*). Our calculations, based on a limited number of available samples, show a gradation of from 80 to 0.3 percent chrysotile in one of the ore minerals, garnierite, and in several processed ores.

Thus, there is ample potential for exposure to chrysotile asbestos among the New Caledonia nickel workers. If these workers are exposed to chrysotile asbestos, lung cancer may be an important disease among them, as it is among other chrysotile-exposed populations throughout the world (*9*). We do not consider this a "weak" hypothesis at all: it originated from documented identification of the presence of chrysotile asbestos in the ores and is supported by studies that show chrysotile to be an agent that in many other circumstances produces precisely the cancer of concern (*10*). On the contrary; if chrysotile asbestos was not associated with lung cancer here, this would attract much more attention.

The occurrence of cases of pleural mesothelioma in New Caledonia is of particular interest (*11*). This neoplasm, rare in the general population, is considered a marker for previous exposure to asbestos. In a series of 110 consecutive cases that they personally observed, Cochrane and Webster found asbestos exposure implicated in 109 (*12*). The association is so strong that, where there is occupational exposure to asbestos, mesothelioma is likely to occur with increased frequency.

We are pleased to read that Société Métallurgique Le Nickel–SLN has now set up a special department to deal with health hazards and dust emissions at their facility.

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References and Notes

1. A summary of this data base, over the early and mid-20th century, appears in E. Mastromatteo, *J. Occup. Med.* **9**, 127 (1967). The Welsh, Norwegian, German, and Canadian experiences are developed historically. The citation for the Russian report is an abstract. For the refinery at Clydach, Wales, the site for which most data are reported, there was a fivefold excess lung cancer attack rate and a 150-fold excess nasal cancer attack rate [R. Doll, *Br. J. Ind. Med.* **15**, 217 (1958); J. G. Morgan, *ibid.*, p. 224].
2. The lack of health information from the New Caledonia refinery may have been attributable to limited medical surveillance. We have been informed that workers are referred elsewhere for diagnostic workup of chest diseases because of a lack of medical expertise on the island. Therefore, it is reasonable to expect that the diagnosis of mesothelioma, primary lung cancer, and nasal cancer went underreported.
3. R. Lessard, D. Reed, B. Maheux, J. Lambert, *J. Occup. Med.* **20**, 815 (1978).
4. Each criticism of Meininger *et al.* may be answered with plausible counterarguments. For example: (i) Although primary and metastatic lung cancers were not differentiated in this study, neither were other cancers considered which may have been metastatic from the lung (for example, brain tumors). (ii) The rise in the world incidence of lung cancer during the decade preceding the New Caledonia study, against which the island rates were compared, is a difficulty of the analysis. What is significant in (*3*) is the higher rates of lung cancer observed among the New Caledonia population as compared to those of other South and Central Pacific countries, with the same data base used in each case. (iii) The control group used by Lessard *et*

al. was not representative of the general population on the island in that it consisted of outpatients from the Noumea Hospital laboratory. Individuals observed in an outpatient clinic, and treated for medical reasons, tend to have more medical problems than people who do not visit such a clinic. Therefore, differences in control and study groups tend to be lessened. But, as noted, in retrospective studies there are inherent difficulties in evaluating cancer incidence. However, the study by Lessard *et al.* made the important contribution of calling attention to a potential problem.

5. Exposure to many agents has been implicated, as in the etiology of lung and sinus cancers in nickel workers. Cancer of the sinus has been considered by some a result of exposure to nickel carbonyl; the lung cancers are associated with more complex exposures. These are reviewed in Mastromatteo's paper (*1*); among the suggested agents are arsenic compounds. Morgan (*1*) stated that "workers showing an increased incidence of respiratory cancer were those involved in dusty operations rather than those exposed to nickel as a gaseous compound." The question of identifying the carcinogens has not yet been resolved.
6. An overview of the silica problem was described by A. M. Langer in *Maxcy-Rosenau Public Health and Preventive Medicine*, J. Last, Ed. (Appleton-Century-Crofts, New York, ed. 11, 1980), pp. 637–641. A study by B. Gylseth and T. Norseth implicated fibrous amphibole gangue minerals in their case reports (*Am. J. Ind. Med.*, in press).
7. A. M. Langer, A. N. Rohl, I. J. Selikoff, G. E. Harlow, M. Prinz, *Science* **209**, 420 (1980).
8. G. Troly, M. Esterle, B. Pelletier, W. Reibell, in *Proceedings of the American Institute of Mining, Metallurgical, and Petroleum Engineers Laterite Symposium* (American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 1979), pp. 85–119. This detailed geological report is at variance with the assertion of Meininger *et al.* concerning the absence of chrysotile in the ore as a result of the weathering process. The island peridotites (used in the generic sense) are totally serpentinized along major thrust plates and fault zones. Moreover, diffuse bodies of serpentine appear within the mafic body with no visible structural control. Essentially, serpentine may occur anywhere; the major portion of the peridotites is referred to as *facies normale*, which is 40 to 79 percent serpentinized; the serpentines in the ultramafic bodies consist primarily of lizardite and chrysotile; the "surficial weathering" of the serpentinized peridotites (the process that accounts for the nickel concentration) follows a five-stage gradational series in which an end product contains completely destroyed chrysotile. However, serpentine minerals are not attacked before stage 3; the nickel ore, with a tenor between 2.0 and 3.0 percent, occurs throughout the alteration zone and includes a 3 percent nickel zone associated with unaltered to slightly altered serpentine (including chrysotile) in stage 3. This is to be anticipated in an alteration continuum; x-ray diffraction analysis of the weather ore zone, called saprolite, shows line-broadened serpentine peaks present, with changes in intensity that could be explained on the basis of particle size and orientation as well as a change in crystallinity; saprolite ores have been shown to contain abundant residual serpentine minerals (lizardite and short chrysotile fiber); within the saprolite ore body are nickeliferous serpentines and a range of "garnierites," a material that is optically homogeneous and nickel-enriched. Garnierite from this island has been shown by Troly *et al.* to consist of serpentine veinlets in saprolite; although the nickeliferous garnierites are essentially lizardite, the magnesium-rich varieties contain a great proportion of chrysotile; the degree of weathering in the four types of saprolitic ores on New Caledonia ranges from complete to incomplete; the peridotites range from highly to weakly serpentinized. Extensive tectonic activity has thrust a number of highly serpentinized zones into weakly serpentinized zones and vice versa, so that they are often juxtaposed. Superimposed fracturing and topographic factors have produced an enormously complex ore body in which chrysotile fiber contamination may range significantly.
9. A general review of chrysotile and its biological effects in man may be found in *Asbestos and Disease*, I. J. Selikoff and D. H. K. Lee, Eds. (Academic Press, New York, 1978).
10. See, for example, the chrysotile data for human populations in the following: *Evaluation of Carcinogenic Risk of Chemicals to Man*, vol. 14, *Asbestos* (International Agency for Research on Cancer, Lyon, 1977); I. J. Selikoff and E. C. Hammond, Eds., *Health Hazards of Asbestos Exposure* (New York Academy of Sciences, New York, 1979); J. C. Wagner, Ed., *Biological Effects of Mineral Fibers* (International Agency for Research on Cancer, Lyon, 1980).
11. There are unconfirmed reports that during the past few years, mesothelioma and lung cancer have occurred in the nickel workers. These reports were not compared to any incidence base, nor were they independently verified clinically or pathologically. Clearly, it would be advantageous to evaluate the entire clinical situation.
12. J. C. Cochrane and I. Webster, *S. Afr. Med. J.* **54**, 279 (1978); *ibid.* **59**, 848 (1981).

5 November 1981

Deforestation and Increased Flooding of the Upper Amazon

In their report on deforestation and flooding in the upper Amazon basin, Gentry and López-Parodi (*1*) draw a number of hydrologic conclusions that are not supported by their evidence.

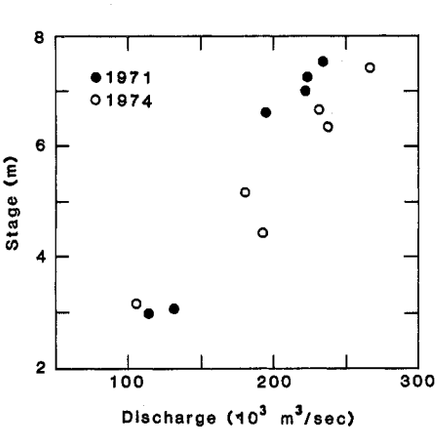
For example, by comparing the mean flood stage (*2*) for 1962 to 1969 with the mean for 1970 to 1978, they conclude that ". . . the runoff of water from upper Amazonia has increased during the last decade." This conclusion requires the assumptions that river stage correlates directly and consistently with river discharge, and that the peak stage is some index of runoff. The relation between water discharge and stage has never been established for the gage at Iquitos, and therefore neither assumption is supported by data. Rivers with beds of fine sand where the bed configuration changes with time and discharge usually have unstable stage-discharge relations. Farther down the Amazon, frequent changes in the configuration of the sandy stream bed are at least partly responsible for the shifting relation between stage and discharge observed at Óbidos, Brazil (Fig. 1) (*3*). The bed of the Amazon at both Óbidos and Iquitos consists of highly mobile fine sand (*4*), so the stage-discharge relation at Iquitos probably is no more stable than that at Óbidos.

Stage-discharge relations also can change as a result of changes in channel cross section. For the Mississippi River at St. Louis, Belt (*5*) has reported that the river stage at a discharge of 24,100 m^3/sec was 3 m higher during 1973 than it was during 1881. He attributed this change to the artificial constriction of the channel. The Amazon has not been subjected to artificial control, but the channel thalweg at Iquitos has shifted appreciably during recent decades. Much of the flow of the Amazon has shifted from the far side of Padre Island to the side nearest Iquitos, the apex of the meander upon which Iquitos is located has slowly migrated downstream, and the impinging flows have accelerated erosion of the riverbank (*6*). The possibility that the stage-discharge relation was affected by the shifting thalweg and bank erosion should be considered.

Gentry and López-Parodi dismiss the possibility that the apparent increase in annual peak stages at Iquitos for 1970 to 1978 is due to an increase in precipitation during the same period, even though all eight stations show higher average annual precipitation for 1970 to 1978 than for 1961 to 1969. They draw their conclusion partly from the observation that 1978

Table 1. Average annual flood stage for the Rio Negro at Manaus; S.D., standard deviation.

Period	Years	*N*	Mean	S.D.
1	1942–1956	15	28.06	0.74
2	1957–1969	13	27.27	0.63
3	1970–1980	11	28.42	0.92
Record	1903–1980	78	27.69	1.17



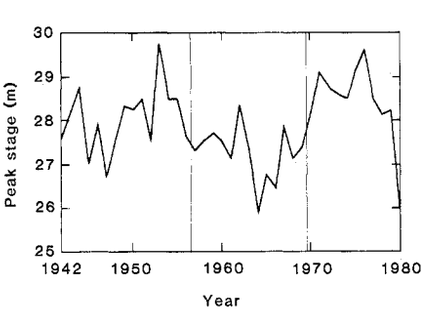


Fig. 1 (left). Relation between stage and discharge, Rio Amazonas at Óbidos (*3*). Fig. 2 (right). Peak stage of the Rio Negro at Manaus, 1942 to 1980 (*3*).

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