



專訪中興大學生命科學系林幸助教授 台灣溪流生態的 生機與危機

Life and Crisis in Taiwan's Streams

An Interview with Prof. Hsing-juh Lin Department of Life Science, NCHU

溪流是台灣的血脈。這個地處亞熱帶的蕨類小島，季風與颱風定期帶來豐沛雨水，4百多條大大小小的溪流以中央山脈為分水嶺，自山巒崩塌而下，雕塑出台灣凹凸有致的地貌，向四周奔流入海。

台灣的溪流是典型的熱帶亞熱帶島嶼溪流，「坡陡流速」是最主要的特徵，但400多條溪流中，主流長於4公里而流域面積大於10平方公里的只有105條，而且大多數溪流的長度都只有數十公里。而由於中央山脈山脊偏東的缘故，東部溪流又比西部溪流更為短小，地形也更為陡峭。

受到季風氣候影響，台灣的乾濕季十分明顯。對溪流而言，每年的5到10月是豐水期，水流量大且流速快，颱風暴雨來臨時經常導致溪水暴漲，釀成災害。11月到4月則是枯水期，水流量少且速度緩慢，河床乾涸裸露，有些溪流甚至流不到入海口，成為「沒口河」。整體而言，台灣的溪流豐枯變異十分懸殊，這種情況在中南部與東部的溪流又比北部溪流更為明顯。

As a tiny island in the subtropics, Taiwan receives abundant rainwater regularly from the monsoon and typhoons, and the 400 or so streams work as arteries that carry the water outwards from the watershed – the Central Mountains, leaving behind a trail of curvy terrain before they join the sea.

Taiwan's streams are typical subtropical island streams, and their main feature is "steep slope and rapid current." However, only 105 of the streams in Taiwan have a main stream longer than 4 km and a drainage area greater than 10 km². Most of them are only a few dozen km long, and the ones in the east are shorter and steeper than the west counterpart since the Central Mountains' ridges lean towards the east.

Due to the monsoon climate, Taiwan has distinct dry and wet seasons. The rich water period is from May to October, and typhoons often cause streams to flood due to the amount and speed of water flow. Nov.-April is the low water period, during which the amount and speed of water is low, riverbeds are dried and exposed, and some streams can't even make it to the sea. Overall, Taiwan's streams are very different, especially more so in central/southern/eastern Taiwan when compared to northern Taiwan.



1. 樹梢透綠蔭，溪水透心涼。雪霸國家公園七家灣溪時時美景動人，溪流更孕育了珍貴物種／吳志學攝

Light green trees and the cool stream. Cijawan Creek. Stream in SPNP is not only beautiful but is also home to many species. / Photo provided by Chi-feu Wu

2. 高山深潭天數風季助水流湍急，大石灘底下就成為鮭魚的避風所／林幸助提供

Boulders are havens for salmon during Gaoshan Stream's flooding in typhoon seasons. / Photo provided by Hsing-juh Lin





逆中求存的溪流生態

「對於生物來說，台灣的溪流是非常嚴厲的環境。」多年來專門研究水域生態的林幸助教授表示，台灣溪流環境的變化實在太大，夏天時溪水湍急，水中生物不論藻類昆蟲魚蝦蟹統統被沖走了，冬天則進入缺水的乾旱期，生物也不易存活。

是故，台灣溪流的生物多樣性並不高。整個溪流生態系的組成，植物方面包括藻類、水草與沿岸植被，動物方面則有水棲昆蟲、螺貝、蝦蟹、魚類、兩生爬蟲類和鳥類等等。為了深入了解溪流生態體系的組成與功能，以及人為因素對溪流生態的影響，近幾年林幸助教授和諸多水文、地理、土壤各領域的環境專家，和研究各種動植物的生物學者，共同從事水域生態整合型研究計畫，以宏觀的方式來建構生態與環境模式，探討生物與環境因子的交互作用，並從食物網的角度來觀察不同生物彼此之間的關聯性。

「為了要適應這樣劇烈的環境，許多溪流生物已經演化出一套特殊的生存機制。」林教授指出，歐美溫帶地區許多溪流魚類都在春夏繁殖，但是台灣的溪魚則選擇在秋天產卵，冬天孵化，到了春天，藻類生長、水棲昆蟲也多，小魚就有足夠食物可吃，等到夏天，才有足夠力量抵禦強勁水流。

Harsh Streams for Ecosystems

"Taiwan's streams are tough places to live for life forms," said Prof. Hsing-chu Lin, an expert on water ecosystem, who pointed out that Taiwan's streams have drastic changes: the rapid current in summer flushes away all kinds of life forms, and the drought in winter isn't any better, either.

This is why the biodiversity in Taiwan's streams isn't very high; the plants found here include algae and vegetation along the banks, and animals include aquatic insects, spiral shells, shrimps, crabs, fish, amphibious reptiles, and birds. In order to understand the nature of stream ecosystem and human influences on them, Prof. Lin has been working with experts on water, geography, soil, and wildlife to conduct integrated research on water ecosystem, establish the interaction model between ecosystem and environment from a macro perspective, discuss their interactions, and observe the relationships between species in the food network.

"Many life-forms have developed unique mechanisms to survive in such harsh conditions." Prof. Lin pointed out that fish in many streams in the temperate zone reproduce in spring/summer, but the counterpart in Taiwan spawn eggs in fall which hatch in winter. In spring when algae and aquatic insects are abundant, small fish would have enough food and be able to stand the current in summer.

台灣溪流兩生類的生殖季也不在萬物勃發的春天，而是秋末冬初的時節。根據中興大學生命科學系吳聲海教授在七家灣溪所作的研究，這裡的盤古蟾蜍和赫德氏赤蛙，蝌蚪都在秋冬孵化，一出生就得面對山區寒冷的水溫。但儘管如此，還是比在春夏時被洪水沖走要好得多。此外，牠們的習性甚至外型也都和在地塘鰻行的種類有所不同，譬如為了適應流水環境，溪流兩生類的蛙卵會沉在水底而非浮在水中，蝌蚪的身體也變得較扁平，低溫也致使牠們成長速度較慢，變態後的小蛙體型較大，而且海拔越高，蛙類成長壽，七家灣溪的蛙齡甚至可達8歲！

位於雪霸國家公園的七家灣溪，同時也是台灣的國寶魚——櫻花鉤吻蛙的唯一棲地。這種冰河時期孑遺物種屬於寒帶蛙類，卻在亞熱帶與熱帶交界的台灣發現，成為眾所矚目的生物地理奇蹟。只能生長在水溫攝氏16度以下的櫻花鉤吻蛙，原本洄游在大海與河流之間，但冰河期過後氣溫上升，櫻花鉤吻蛙只好逐漸遷往高海拔的上游，最後竟然不再降海，變成陸封型的蛙類，進而演化成台灣特有亞種。

這些活躍在高山溪流生態系中的生物，通過了天候的嚴峻考驗，發展出獨特的生活史，不僅讓我們見證到生命的奧妙與靈巧，也展現出自然環境的改變對於生物存活方式的巨大影響力。

The procreation season for amphibious life-forms in Taiwan's streams is between in late fall and early winter instead of spring. The study by Prof. Sheng-hai Wu (in Lin's department) in Cijawan Creek shows *Bufo barkowensis* and *Rana saueri* hatch in fall/winter and face cold water. Even so, it's still better than being flushed away by flood in spring and summer. Moreover, their habits and even appearances are different those that grow in ponds. For example, in order to adapt to the flowing water, the eggs of amphibious life-forms are laid deep in the water rather than on the surface, and the tadpoles are flatter and grow slower due to the low temperature, and the frogs at higher elevations also have longer life spans.

Located in SPNP, Cijawan Creek is the only habitat for Taiwan's treasure, *Onychomystus masou formosanus*. Found in the frigid zone, it is the survivor of the ice age, and the fact that it is found in Taiwan where the subtropical and the torrid zones meet is a true wonder. Requiring water lower than 16 degrees Celsius, this species originally move between seas and rivers, but the temperature rise after the ice age caused them to go to higher elevations. Eventually, they no longer return to the sea and have become a land-locked salmon that is unique to Taiwan.

These life-forms have passed the stringent tests of nature and developed unique ways of life. We do not just witness how "life finds a way" but also nature's deep impact on how life sustains.



1. 溪流有「自淨作用」，只要不再繼續污染干擾，經過休養生息，溪水會自動變得清澈。圖為碧綠溪／鄭進元攝
Streams are capable of self-cleaning and will become clear again as long as the pollution stops. Shown here is Bihy River. / by Jin-yuan Dai
2. 台灣溪流環境變化大，豐水期水漲漲，冬天則進入缺水的乾旱期。圖為春天七家灣溪／林學助提供
Taiwan's streams have great environmental changes: rich water flow in spring and drought in winter; shown here is Cijawan Creek in the spring season. / Photo provided by Hang-juh Lin
3. 七家灣溪的水庫和攔沙壩對生態系的影響巨大，上下游物種的基因交流也完全被阻絕。圖為七家灣溪／林學助提供
Reservoirs and check-dams in Cijawan Creek have major effects on the ecosystems by cutting off genetic exchanges between upstream and downstream species. / Photo provided Hang-juh Lin

人為開發 溪流缺氧

溪流生態是如此迷人，但可悲的是，目前台灣稱得上乾淨的溪流已經所剩無幾。溪邊戲水的美好畫面早已成為一去不復返的童年回憶，現在的孩子只能在充滿消毒水味的游泳池裡玩水。形形色色的廢水直接灌入河中，垃圾隨波盪漾，溪流變成了污物的天然輸送帶。更不用說水裡的魚蝦驟減，就算捕到了，大家也不大敢吃。

儘管生物們為了適應環境慢慢改變自己的生活習性，卻仍不敵人類過度利用溪流所造成的劇烈變遷。根據林幸助教授多年來在台灣各地溪流的上中下游所作的研究，他認為台灣的溪流生態可說是「自然環境先天不良，人為開發雪上加霜。」

目前台灣溪流的中上游面臨的主要問題，就是農業開發。當我們享受著甜美的高山蔬菜和水果時，可曾想到

這代價竟是由溪流償付。首先，人們截取了大多數的水用來灌溉，導致水源枯竭。接著，農墾殘餘的肥料滲入土中，流進溪流，這些過剩的營養鹽將導致藻類大量孳生，形成所謂的「優養化」現象——為了分解這

Streams suffocated by Industrial Development

The sad thing is there aren't many clean streams left today in Taiwan. Playing in the streams is a distant memory, and today's children could only play in swimming pools full of bleach. All sorts of wastewater and garbage is being dumped in rivers, turning them into conveyor belts for waste. The amount of fish and shrimps in the water is also plummeting, and they are often too contaminated to be consumed anyways.

Although life-forms gradually change themselves to adapt to nature, they can't fight the drastic changes caused by mankind's abuse of streams. Based on his studies on Taiwan's stream systems, Prof. Lin has concluded that "the originally environment isn't good enough, but people are making it even worse."

The main problem with Taiwan's up- and mid-streams is agricultural development, and not many of us think about how streams are sacrificed for the vegetables and fruits on our plates. First of all, most of stream water is used for irrigation, cutting off the supply. Then, excessive fertilizer reaches the streams and cause algae to grow, resulting in the "eutrophic condition." In order to decompose the organic substances generated by dead algae, oxygen in water is being depleted, suffocating many water life-forms.

Odorous algae worsen the water quality, and some forms of algae are also toxic; they don't just harm aquatic





些藻類死亡後的有機物質，溪流耗盡氧氣，水中生物因此窒息而死。

帶有臭味的藻類會讓水質惡化加劇，某些藻類甚至有毒，不僅會危害水中其他動植物的生命，也會污染人類飲用水，引發諸多疾病。譬如惡名昭彰的微囊藻，就有「水庫殺手」之稱。此外，農藥也是毒化水質的禍首之一。

再繼續深究，為了開墾農地，就必須先把沿岸植株砍掉。然而樹木具有涵養水源的功能，大雨來時，樹木的根系可以先包藏水分，之後再慢慢釋放，除可穩定土壤的溼度，也能防止溪水暴漲。樹木也能過濾水質，譬如農墾肥料流入水中之前，樹木會幫助吸收這些多餘的營養。再者，沿岸植物還可以擋住陽光，使水溫變化不會那麼劇烈，對於某些對水溫特別敏感的物種如櫻花鉤吻蛙而言，這一點格外重要。

一旦沿岸植株被砍伐殆盡，便喪失了調節水量、水質和水溫的功能，洪水、污染和生態失衡等問題隨之而來。林幸助教授的研究團隊曾經做過武陵地區3條溪流的比較，其中有勝溪沿岸為無植被的重度農耕地，高山溪沿岸為原始林，七家灣溪的農耕狀況則介於中間。結果顯示，有勝溪的營養鹽含量和水溫最高，因此藻類豐度也最高，水質明顯地劣於其他兩條溪流。

life-forms but also contaminate our drinking water. For example, the notorious microcysts bloom is also known as the "reservoir killer." Pesticides are also making the matter worse.

Further studies show trees along the streams are chopped off in order to acquire land. However, trees help retain water since their roots hold water and release it gradually, this doesn't only stabilize soil moisture but also prevent flooding. Trees also filter water, for example, they absorb excessive fertilizers before they reach the water. In addition, trees block out the sun and help maintain a stable water temperature, which is extremely important for species that are heat-sensitive, such as *Onychomantis masou*.

Once the trees along streams are all gone, the stabilization of water quantity, quality, and temperature disappears, and flooding, pollution, and ecological imbalance emerge. In Wulin, where the banks of Yu-sheng Stream have no vegetation due to farming, Gao-shan Stream's banks are untapped woods, and Chi-jia-wan's condition being in between, Prof. Lin's research clearly shows Yu-sheng Stream has high levels of nutrients and temperature, resulting in algal overpopulation and poor water quality.



1. 武陵地區的有勝溪已變為農化。／林幸助提供
Too much nutrient in Wuling's Yousheng Creek. / Photo provided by Hsing-juh Lin
2. 溪流匯聚了天隆甘蜜、波美等農作物養生。圖為合歡溪／賴進元攝
Streams being nourishments to the life on this island and are a means for people to survive. Shown here is Hehuan River. / by Jin-yuan Dai
3. 在享受甜美高山蔬果時，可曾想到這些代價竟是由溪流償付！／呂建發攝
Who would have thought the price for the delicious produce is paid by the streams? / by Jian-fa Lyu



林幸助教授也提到，七家灣溪的水質這幾年來有明顯的改善，都要歸功於雪霸國家公園與武陵農場共同努力將附近農地陸續收回，改種原生樹種的緣故。

而農業僅僅是水污染當中的一隅而已，畜牧業也將大量的動物排泄物傾入河中，「一頭豬產生的污水量相當於6個人。」林幸助教授說，工業廢水的污染更是多樣化，各種重金屬與化學物質讓河川為之變色，魚蝦為之喪命。進到人口繁盛的下游平原地帶，五花八門的民生污水也加入污染行列。

林幸助教授曾經到淡水河下游進行調查，「從華江橋到關渡這一段，水中的溶氧量時常幾乎是零。」這也表示鮮少生物能夠存活其間，腳步遲滯的廣闊大河，實際上已變成一潭死水。

河川整治的迷思

曾經，台灣的溪流是充滿野性的，它從陡峭高山上疾衝而下，彷彿帶著回歸大海的懷抱。但是人類卻總想著要馴服它們，要「整治」它們。水庫、攔沙壩、堤防，都是「人定勝天」思維下的水泥產物。

然而，溪流並不只屬於人類。這些水泥建物或許暫時對人們有所幫助，卻是其他生物羣生難以跨越的障礙。

Prof. Lin said the water quality in Cijiawan Creek is improving a lot, thanks to SPNP and Wuling Farm that turn farms back to native woods.

Agriculture is only a part of water pollution since the livestock industry also dumps animal waste into rivers. "A pig generates waste that is 6 times as much as we do," said Prof. Lin. Industrial waste is even worse: all sorts of heavy metal and chemicals are being dumped into rivers, killing fish and shrimps, and even our water supply when they reach downstream, plain areas.

Prof. Lin had investigated the downstream of Danshuei River. "The amount of oxygen dissolved in water is practically zero between Huajiang Bridge and Guandu." This means no life could exist in this broad river since it has already turned lifeless.

Problems with River Dredging

Streams in Taiwan were once full of life – they rush down from mountains and return to the sea, but mankind is always trying to tame or "dredge" them, and reservoirs, check-dams, or dikes are all products of our belief that "man will triumph over nature."

However, streams don't just belong to us. Although these concrete facilities benefit us, they destroy wildlife's habitats and well-being. Reservoirs and dams have the worse influences because they divide a stream's up and mid-

甚至成為牠們的囚籠。水庫和攔沙壩對生態系的影響最為巨大，這些厚重高聳的水泥牆將溪流的上下游分隔開來，將流水生態系變成了靜水生態系，導致需要洄游的生物再也找不到回家的路，上下游物種的基因交流也完全被阻絕。

林幸助教授的研究團隊曾經在武陵地區的高山溪，研究攔沙壩拆除對於櫻花鉤吻鮭的影響。結果發現拆壩之後，溪中的櫻花鉤吻鮭數量明顯增加。這是因為拆壩後泥沙慢慢流掉，露出底下的大石頭，而鮭魚很喜歡住在大石頭附近，尤其當夏天颱風季節水流湍急，大石頭底下就成為鮭魚的避難所，因而提高了牠們的存活率。

其實台灣的攔沙壩功能很有限，壽命也很短。許多攔沙壩僅在一個颱風過後，一夕之間就被填滿，而被破壞的攔沙壩，已經變成台灣山林中最令人不忍卒睹的景觀。「現在國外流行把攔沙壩拆掉，尤其是已經不具功能的攔沙壩。」林幸助教授認為，台灣這些失效的攔沙壩應早日改善拆除，還給溪流生物一個健康的生存環境。

河川整治工程中常見的溪岸與溪床水泥化，也對水中生物造成極大威脅。許多水生生物都居住在溪床的石縫孔隙中，但鋼筋混凝土則毫無縫隙可讓這些生物居住，讓溪流愈頭愈尾變成了排水溝，而水泥的比熱小，吸熱散熱快速，使得水溫變化更為劇烈，也深深影響溪流生態環境的穩定性。

stream, turning the flowing water into stagnant water, and life-forms that need to return to upstream cannot do so, and genetic exchange between species in different stream sections is rendered impossible.

Prof. Lin's research team investigated Wulin's Gaoshan River to determine the influence of dam-removal on *Oncorhynchus masou formosensis*. They discovered that its population significantly increased after the removal since the boulders underwater were exposed after the covering mud is gone. Salmon love to use boulders as shelters especially during typhoons, resulting in better survival rates.

In fact, Taiwan's check-dams aren't very useful and have short life-spans. Many of them are filled with sediments after a single typhoon, and there are so many abandoned check-dams in Taiwan's woods. "Check-dams, especially the useless ones are being removed in other countries," said Prof. Lin, who believes the check-dams that are no longer useful should be removed in order for stream life-forms to live.

The constructions in river dredging that setup concrete river beds also threaten wildlife. Many aquatic life-forms live in the gaps between stones on the riverbeds, but concrete counterparts do not offer such havens and completely turn streams into drainage lines. Concrete has low specific heat and absorbs and dissipates heat quickly, causing drastic temperature changes and low stability in streams.



1. 溪流顯現出台灣凹凸有致的地貌，圖為七家灣溪／林幸助提供
Streams give Taiwan the rough and uneven terrain. Shown here is Cijawan Creek / Photo provided by Hsing-Juh Lin
2. 台灣溪流的中上游開發的主要問題，就是農業開發／鄭貴義攝
Agricultural development is a major problem for the upstream and midstream of Taiwan's rivers / by Jian-yi Zheng
3. 河川整治工程中常見的溪岸與溪床水泥化，也對水中生物造成極大威脅／林幸助提供
Concrete constructions in river beds also threaten aquatic life forms / Photo provided by Hsing-Juh Lin

林幸助教授提到「洪水脈衝理論」，這個理論認為河川下游原本就有一些該氾濫的地方，這些區塊其實也是生產力最旺盛的地方，定期的洪水氾濫帶來了有機物，分解成為土地的養分，因而更加生機蓬勃。但人類偏偏要與水爭地，想盡辦法圍堵控制水的路線，卻從未能真正擺脫洪水的掣肘。

讓溪流「淨一淨」

如何才能還給後代子孫美麗清澈的溪流？林幸助教授認為，當務之急就是污水處理，即加速污水下水道建設，先把污水截掉，處理得乾淨一點再排進河川，減少後續傷害。另外，土地利用方式的再檢討，溪流沿岸的植被復育，也都是恢復溪流生命力的首要之務。

「治水時要以宏觀角度看整個流域，不能頭痛醫頭、腳痛醫腳」林幸助教授舉例，下游淹水就加建堤防，也許根本於事無補，因為問題可能出在上游森林砍伐太嚴重，真正該做的是復育上游植被。

其實溪流有所謂的「自淨作用」，只要我們能給予溪流充裕的時間和空間，不再繼續污染干擾，經過一段時間的休養生息後，溪水會自動變得澄清，生態也會慢慢恢復平衡。林幸助教授認為，如何讓溪流的自淨功能發揮到極致，將是未來生態工程研究的重點。

溪流是上天的賜予，是所有生物共同的資產。人類不該獨占這項寶貴的水資源，而應該把其他生物看作共享資源的夥伴，尊重牠們的生存權利。否則一旦溪流的生命力不再，人類的生活與文明也將難以為繼。

Prof. Lin also mentioned the "Flood Pulse Theory," which states some downstream places are destined to be flooded, and these areas are actually very fertile. Regular flooding brings organic matter that nourishes land and sustains life, but mankind tries to take land from water and changes water courses. Yet, flooding is still there to haunt us.

Time to Clean up the Streams

How do we make sure our future generations will enjoy clear and beautiful streams? Prof. Lin believes the first task is to setup sewage systems that reduce the amount of waste water and treat water before it joins the rivers. Also, land use needs to be re-examined since vegetation along the banks plays a critical role.

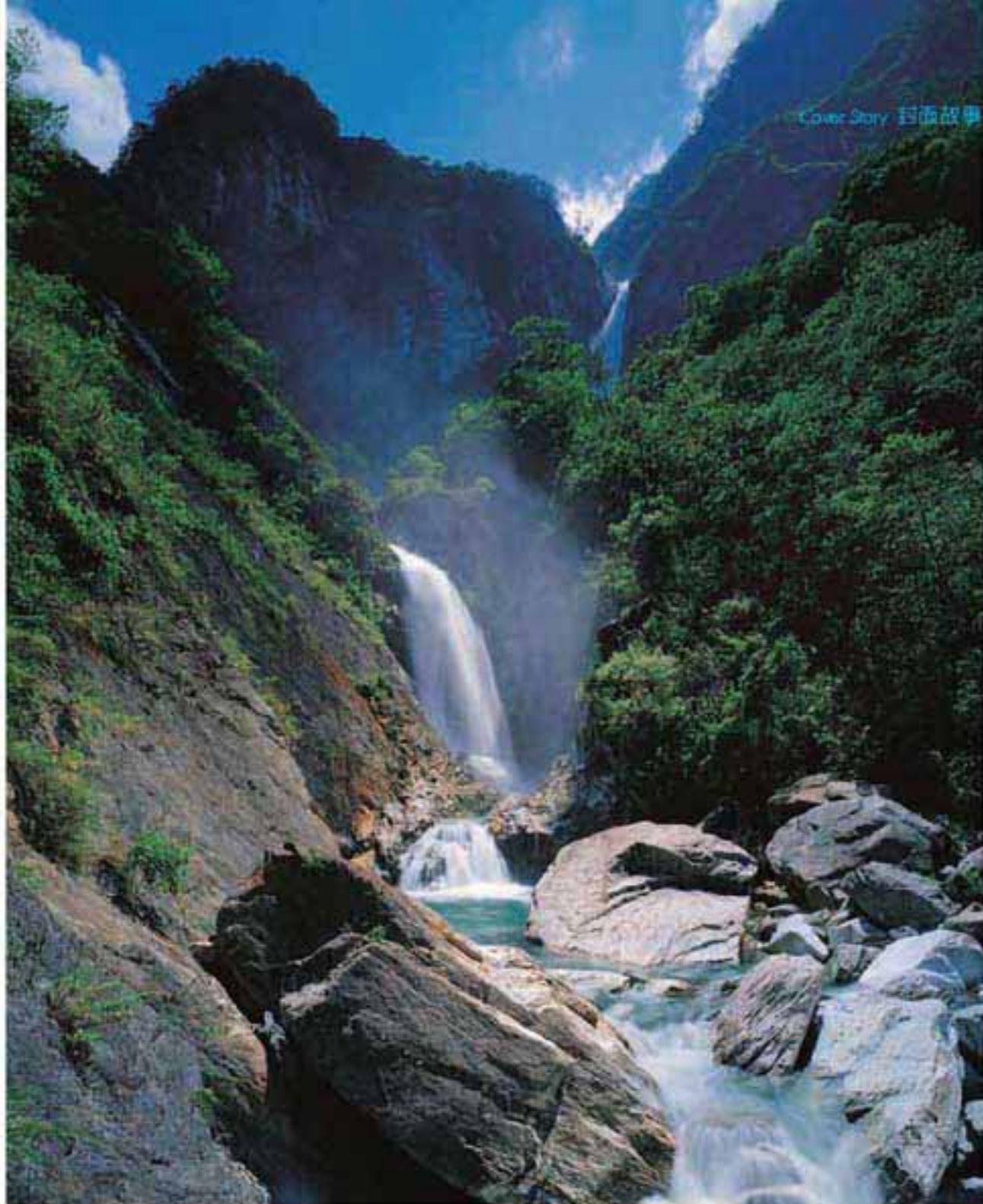
"You need to look at the greater picture when dealing with floods. You can't just treat individual symptoms," said Prof. Lin. Building a dike when the downstream section floods is useless since the real problem may be over-logging in upstream forests, and the real solution is vegetation restoration.

Streams are actually able to clean themselves. As long as we give them enough time, leave them alone, and stop polluting them, they will become clear again after a while, and ecosystems will become balanced. Prof. Lin believes the key of future ecological engineering is how to maximize streams self-cleansing capacity.

Streams are God's gifts to be shared by all life on earth instead of being possessed by humans alone. We should treat other life-forms as partners who share resources and respect their right to live. Otherwise, once the streams lose their life-sustaining capacity, our lives and civilizations will not be sustained, either.



- 1 林教授及助理在高山溪檢測水質 / 林幸助提供
Lin and his assistants checking water of Gao-shan Creek / Photo provided by Hang-juh Lin
- 2 溪流塑造出台灣凹凸有致的地貌，圖為白雲瀑布 / 大曾處提供，黃雲廷攝
Streams give Taiwan the rough and uneven terrain. Shown here is Baiyang waterfall / Photo provided by TNP, taken by Wu-yu Huang



林幸助教授小檔案 About Prof. Hsing-juh Lin

美國羅德島大學海洋學博士，現任國立中興大學生命科學系教授。曾獲海國科會甲等研究獎、國立中興大學青年教師研究獎、中國生物學會研究成就獎。主要研究範圍為溪流、沿海與海洋系統生態學。近年來致力於整合性的溪流沿岸生態系統模式建構與分析，強調以宏觀角度和科學方式探討水域生態與環境因子的互動機制，進而達到生物資源永續保護的目標。

Dr. of oceanography URI. Currently working with the department of life sciences in NCHU. Have received research awards from NSC, teacher's research award from NCHU, and research achievement award from the Biological Society of China. Lin is specialized in the ecology in streams, shores, and oceans; his later works focus on the construction and analysis of integrative stream and coastal ecosystems, and focuses on analyzing the interactions between aquatic ecosystems and environmental factors through macro perspective and scientific methods in order to achieve conservation and environmental protection.